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ART. XXXII.—*Notice of Berthelot's Thermo-Chemistry;* by J. P. COOKE, JR.

THE new work of M. Berthelot, entitled "Essai de Mécanique Chimique fondée sur la Thermo-chemie," presents for the first time in a systematic form the results accumulated during the past ten years from one of the most fruitful fields of investigation ever opened to the chemist. The book supplies a most important want, for the details of the work—published in numerous separate papers rapidly following each other in the chemical journals—have been almost unintelligible, except to those who have followed the investigation from the beginning, and no connected statement of the general principles involved was accessible to the student. The work in this new field has been done almost wholly by two investigators, Berthelot, of Paris, and Thomsen, of Copenhagen. Guided by different theoretical views, these skillful experimenters have gone over very nearly the same ground, and their united testimony, concurrent as it is in most cases, gives a certainty to the results obtained which is as fortunate as it is unusual when the field explored is so extensive as the one we are considering. These two men alone could write authoritatively on the subject, and it is, perhaps, fortunate that the first presentation should come from M. Berthelot, who has the usual skill of his nation in exposition and generalization.

In his introduction, Berthelot enunciates the fundamental principles of thermo-chemistry under the three following heads:

Principle of Molecular Work.

I. The quantity of heat evolved is the measure of the sum of the chemical and physical work accomplished in any reaction.

Principle of Conservation of Energy.

II. When a system of bodies—simple or compound—starting from a given condition undergoes either physical or chemical changes, which bring it into a new condition without producing any mechanical effect on external bodies, the amount of heat evolved or absorbed—as the total result of these changes—depends solely on the initial and final states of the system, and is the same, whatever may be the nature or order of the intermediate states.

Principle of Maximum Work.

III. In any chemical reaction between a system of bodies not acted on by external forces, the tendency is toward that condition and those products which will result in the greatest evolution of heat.

The first two of these principles are direct deductions from the mechanical theory of heat; but the third is a generalization, which Berthelot claims as original, and, if so, it is his greatest contribution to this department of the science. In the work before us the two first principles are discussed in the first volume, and this discussion, together with a description of the methods of experimenting and an enumeration of the numerical data thus far obtained, fill nearly 600 large octavo pages; while the discussion of the third principle occupies a second volume which is still larger. We will follow the same order in the few remarks which the limits of a short notice permit.

As the announcement of an almost axiomatic principle of thermo-dynamics, which every investigation of thermo-chemistry necessarily assumes, the first of these general principles has an appropriate place at the opening of a discussion of the subject. In regard to heat, as in regard to other manifestations of energy, the total effect is equal to the sum of all the partial effects. But Berthelot adds to his statement of the Principle of Molecular Work the remark—"This principle furnishes the measure of chemical affinities." When, however, we come to his discussion of this general principle, we are disappointed to find that the whole subject is summarily dismissed without giving the reader any clear conception of the distinction between the two modes of change whose results are so inextricably blended in all chemical processes.

Were we able to distinguish between chemical and physical change, the first principle would undoubtedly give us a measure of what we might then clearly define as chemical affinity or

chemism. Not only, however, is it, at present, impossible to eliminate from our results the effects of physical changes; but, moreover, when we study the details of the chemical processes with which we are most familiar, we are surprised to find to what a large extent the thermal effect depends on the changes in the obviously physical condition which the process involves. For example, in the formation of hydrogen gas from diluted sulphuric acid and zinc, the passing of a solid into a liquid, on the one hand, and the development of a gas from a liquid, on the other, involve physical changes which very largely control the amount of heat developed in the process, and, therefore, also according to the third principle, control the process. Indeed, as is well known, all chemical action ceases as soon as the water becomes saturated with zinc sulphate, although a large excess, both of sulphuric acid and of zinc, may be present. But, after making all allowances for the potency of physical conditions, it would undoubtedly appear from the present standpoint of Chemistry that there must be certain differences of qualities inherent in the atoms, which correspond to differences of chemical affinity and which are important factors in determining chemical changes, and it is certainly legitimate to seek to measure what we may call the relative potential of the atoms when in a state of indefinite expansion. It is obvious, however, from Berthelot's discussion of the subject, that we are, as yet, far from realizing such a result. In fact, the only case in which he claims that we measure directly the heat of chemical action independently of physical changes is in the well-known reaction $H_2+Cl_2=2HCl$, which is attended with the evolution of 22 units of heat for every 36·5 grams of hydrochloric acid gas formed. Since in this case the volume of the æriform compound is equal to the sum of the volumes of the two elementary gases from which the compound has been formed, and since, moreover, there has been no essential change in the specific heat, we may reasonably infer that the heat evolved results from chemical action only. But, according to the theory which is accepted by the great majority of chemists, this chemical action is by no means so simple as the direct union of two gas volumes would seem to indicate; for, as our symbols show, the process implies the parting of the similar atoms which are united in the molecules, both of hydrogen and of chlorine gases; and, unless we misinterpret a very large number of facts, this separation implies the expenditure of a no inconsiderable amount of mechanical work, and may imply a change of physical condition as well. Berthelot, in common with a school of French chemists, rejects the modern theory based on the assumption of the equal molecular volumes of all substances when in the state of gas, and uses throughout his

work the chemical equivalents of the older chemistry in place of the atomic weights of the new. At the same time he accepts fully the mechanical theory of heat and the conceptions of molecular work which this theory implies. To those who consider that Avogadro's Law, and, therefore, the modern theory of chemistry are direct deductions from the mechanical theory of heat, this course seems inconsistent, and this inconsistency deprives the work of a very considerable degree of simplicity which might otherwise have been secured. The remarkable progress made in organic chemistry during the last twenty years has resulted almost wholly from the circumstance that the investigators have worked back from the elementary substances to the elementary atoms and discussed the various modes in which these atoms might be grouped in the molecules. In the same way in thermo-chemistry we shall find no satisfactory basis until we go back likewise to the atoms and discuss the thermal effects which attend their union or their separation. One generalization we can already make in regard to atomic work with a great degree of certainty;—that the union of atoms is attended with the evolution of heat and the parting of the same atoms in the same associations with an equal absorption of heat:—and it must be remembered that, as defined by modern chemistry, atoms are definite masses of matter, so that in enunciating this general principle we refer to a palpable effect as resulting from a well-defined process, entirely independently of the theoretical views we may have in regard to the nature of the chemical atoms or of the modes by which they are united and grouped together. The general principle just stated explains a great many facts of thermo-chemistry which are otherwise anomalous and obscure. It moreover gives us the basis for a clear theoretical distinction between a chemical and a physical process, the first consisting in the separation or union of atoms, the last in the separation or drawing together of molecules. It is true that the distinction here drawn is, as yet, theoretical; but the theory involved gives us a basis from which to work, and this is enough for the present. The problem of finding what we have called the thermal potential of the atoms is not more remote than many problems which have been successfully solved in organic synthesis, and it is in this direction, as it seems to us, that we can alone expect to reach a measure of chemical affinity. It may, indeed, be found that the problem cannot be solved and attempts to solve it may lead to results which will modify or supplant our present theories. It may appear that the difference between a chemical and a physical process is one of degree and not of kind; but, whatever the result may be, there can be no doubt that the investigation will lead to larger knowledge and clearer conceptions.

As it seems to us the principle of molecular work should be supplemented by the principle of atomic work, and it is certain that neither clearness of conception nor definiteness of statement has been gained by the obvious attempt to avoid the recognition of the modern theory of chemistry.

We readily accept Berthelot's second fundamental principle of thermo-chemistry when enunciated as above, because it so obviously falls under the general law of conservation of energy; but it is obvious that this principle could not have been assumed prior to its experimental verification, any more than could the principle of the conservation of mass, prior to the experiments of Lavoisier, and as Lavoisier worked out this last great principle with the balance, so Berthelot and Thomsen have demonstrated with the calorimeter the corresponding fundamental principle of thermo-chemistry, which must be regarded as a generalization from the results of their work. Moreover, although in cases of simple direct combination the principle under discussion is almost self-evident, and has been long admitted, yet, before the investigations of Berthelot and Thomsen, no chemist conceived of its application in the very complex and indirect reactions by which the greater part of the thermo-chemical data have been obtained. It must be remembered that very few processes of direct chemical combination fulfill the conditions which an accurate measure of the accompanying thermal change involves, and a vast amount of chemical knowledge and ingenuity has been shown in devising indirect methods by which the results could be reached. The general theory of these indirect methods may be stated thus: We arrange two systems of reactions, both of which begin with the same factors in the same conditions, and end with the same product in the same conditions. In one of these series of reactions there must be no process whose thermal result—if not already known—cannot be measured with the calorimeter. In the other series the chemical combination or decomposition, whose thermal effect we are investigating, enters as an unknown term, the effect of the other chemical changes involved being known or capable of measurement, as in the first series. It follows now, from the principle we are discussing, that if we subtract the sum of the quantities measured in the second series from the sum of those measured in the first series we shall have the value of the unknown quantity. An example will make the method more intelligible.

It is required to determine the heat evolved when aluminum combines with bromine to form Al_2Br_6, and in the following scheme we assume, as is usual in this subject, that the chemical symbols stand for a number of grams corresponding to the atomic weight, and that the amount of heat is expressed in

gram units. Two series of reactions may now be arranged so as to fulfill the conditions we have assumed—

First Series.

K_6+Br_6 (gas)$+Aq=(6KBr+Aq)$	570,000 units.
$Al_2+Cl_6=Al_2Cl_6$	321,800 units.
Al_2Cl_6 dissolved in $(6KBr+Aq)$	152,000 units.
	1,043,800 units.

Second Series.

$K_6+Cl_6+Aq=(6KCl+Aq)$	604,800 units.
$Al_2+Br_6=Al_2Br_6$	x units.
Al_2Br_6 dissolved in $(6KCl+Aq)$	173,800 units.
	778,600 units.

$$x+778{,}600=1{,}043{,}800. \quad x=265{,}200.$$

In studying these two series of reactions it will be evident that we begin in each case with the same amounts of the same elementary substances, namely: K_6, Al_2, Br_6, Cl_6, and that we end with aqueous solutions in the same condition. Hence, the total amount of heat evolved in each of the two series must be the same, and we can at once deduce the value of the only unknown quantity. In this determination the only quantities which had to be measured at the time were the heat of solution of aluminic chloride in an aqueous solution of potassic bromide, on the one hand, and the heat of solution of aluminic bromide in an aqueous solution of potassic chloride, on the other, using, of course, equivalent quantities in each case. The other values given had previously been determined by indirect methods, and it can easily be seen that the investigation displays not only a great command of knowledge but also a great fertility of invention, and yet this is a comparatively simple case.

As deductions from the general principle of the conservation of energy, Berthelot gives a large number of theorems which serve to illustrate the extent and variety of its application to the study of the thermal changes which accompany chemical reactions. We give two as examples:

THEOREM III.—*In two series of reactions starting from different initial conditions, but ending in the same final state, the difference in the quantities of heat evolved is equal to that which would be evolved in passing from one of the initial states to the other.*

This theorem enables us to determine very simply the amount of heat evolved in the formation of the definite hydrates, although it would be very difficult if not impossible to form these substances with a definite composition in the calorimeter. Thus, to determine the heat evolved in the reaction $SO_3+H_2O=H_2SO_4$, we have only to dissolve in one experiment SO_3 and in another H_2SO_4 in a comparatively large amount of

water when the difference in the heat evolved in the two cases will be the quantity required. So, also, the heat of formation of a hydrocarbon may be determined by comparing the heat of combustion of the compound with the heat of combustion of the hydrogen and carbon of which it consists. Thus the heat of combustion of acetylene C_2H_2 (26 grams) has been directly measured and is equal to 321,000 units, while the heat of combustion of C_2 (24 grams) plus the heat of combustion of H_2 (2 grams) only amounts to 257,000 units. Hence, it is evident that in the formation of 26 grams of acetylene 64,000 units are absorbed. Acetylene, indeed, belongs to a class of compounds whose formation is attended with the absorption of heat. This class of compounds which have a special interest in thermo-chemistry are said to be endothermous, while by far the larger class of compounds whose formation is attended with an evolution of heat are said to be exothermous.

THEOREM VI.— *When a compound gives up one of its elements to another body, the heat evolved in the reaction is the difference between the heat of formation of the first compound and that of the resulting product.*

Thus, when an aqueous solution of chlorine is used as an oxidizing agent, for every eighteen grams of water decomposed 9,600 units of heat are evolved, and this amount is the difference between the heat of formation of H_2O and 2HCl. As can easily be seen, the same theroem applies to the problem presented by explosive agents of various kinds and simplifies the solution to a remarkable extent.

These few illustrations will serve to give a general idea of the mode of investigation in this new field of thermo-chemistry, but they are wholly inadequate to show either the extent of the field or the great skill with which it has been cultivated. We must reserve for another number a notice of some very interesting relations which, under his third fundamental principle, Berthelot discusses in the second volume of his great work.

[To be continued.]

ART. XXXIII.—*The History of some Pre-Cambrian Rocks in America and Europe;* by T. STERRY HUNT, LL.D., F.R.S.

[Read before the American Association for the Advancement of Science at Saratoga, September 1, 1879.]

I. INTRODUCTION

ONE of the earliest distinctions in modern geology was that between the crystalline or so-called Primary strata, and those which are found in many cases to have been deposited upon them, and being in part made up of sediments derived from the disintegration of these, were designated Transition and Secondary rocks. While the past forty years have seen great progress in our knowledge of these younger rocks, and while their stratigraphy, the conditions of their deposition, and their geographical distribution and variations have been carefully investigated, the study of the older rocks has been comparatively neglected. This has been due in part to the inherent difficulties of the subject, arising from the general absence of organic remains, and from the highly disturbed condition of the older strata, but in a greater measure, perhaps, to certain theoretical views respecting the stratified crystalline rocks. In fact, the unlike teachings of two different and opposed schools lead to the common conclusion that the geognostical study of these rocks is unprofitable.

The first of these schools maintains that the rocks in question are, in great part at least, not subordinated to the same structural laws as the uncrystalline formations, but are portions of the original crust of the earth, and that their architecture is due not to aqueous deposition and subsequent mechanical movements, but rather to agencies at work in a cooling igneous mass. The igneous origin of gneisses, petrosilex-porphyries, diorites, serpentines, and even of magnetic and specular iron-ores was held and taught almost universally by our geologists, a generation since, and has still its avowed partisans; some maintaining that these various crystalline rocks are portions of the first-formed crust of the planet, while others imagine them to be volcanic matters extravasated at more recent dates; in either case, however, more or less modified by supposed metasomatic processes. By the term metasomatosis are conveniently designated those changes which are not simply internal (diagenesis), but are effected from without, as a result of which the chemical elements of the original rock are supposed to be either wholly or in part replaced by others from external sources (epigenesis).

The other school, to which allusion has been made, and which, not less than the preceding, has helped to discourage, in

the writer's opinion, the intelligent geognostical study of the crystalline stratiform rocks, is that which believes them to be, in great part at least, the result of chemical changes, often metasomatic in their nature, which have been effected in paleozoic and more recent sedimentary beds, obliterating their organic remains, and transforming them into crystalline strata. According to this view, feldspathic, hornblendic, and micaceous stratiform crystalline rocks, having similar mineralogical and lithological characters, may belong to widely separated geological periods; while the same geological series may, in one part of its distribution, consist of uncrystalline siliceous, calcareous, and argillaceous fossiliferous sediments, and in another locality, not far remote, be found, as the result of subsequent changes effected in these strata, transformed into gneiss, hornblende-schist or mica-schist, by what is vaguely designated as metamorphism.

The recent history of geology abounds in striking illustrations of the fact that in a great number of cases these views have been based on misconceptions in stratigraphy, and without entering into the discussion of the question, it may be said that, in the writer's opinion, careful stratigraphical study will, in all cases, suffice to show the error, both of the plutonic and the metamorphic hypothesis of the origin of crystalline rocks. The former is supported chiefly by the lithological resemblances between certain stratified and unstratified rocks, and by the appearances of stratification occasionally found in these; while the latter is sustained by the analogies offered in cases of local hydro-thermal action on sediments, and by the resemblances which recomposed materials frequently offer to their parent crystalline rocks. It is here maintained that the great formations of stratiform crystalline feldspathic, hornblendic and micaceous rocks, which, in various parts of the world, have been alternately described as plutonic masses, and as metamorphosed paleozoic, mesozoic or cenozoic strata are, in all cases, neptunean rocks, pre-Cambrian or pre-Silurian in age, and that we know of no uncrystalline sediments which are their stratigraphical equivalents.

We have then before us two schools, the one maintaining the secondary origin of a great, and, by them, undefined portion of the crystalline stratiform rocks, while assigning to certain older (pre-Cambrian) crystalline rocks (of which they admit the existence), either a neptunean or a plutonic origin. The other, or plutonist school, while asserting the plutonic derivation of the greater part of the crystalline formations, accepts, to some extent, also, the notion of secondary and neptunean metamorphic schists. It is believed that the above concise statements cover the ground held by the hitherto prevailing neptunean

and plutonist schools, neither of which, it is maintained, expresses correctly the present state of our knowledge. In opposition to both of these are the views taught for the last twenty years by the writer, and now accepted by many geologists, which may be thus defined:—

1*st.* All gneisses, petrosilexes, hornblendic and micaceous schists, olivines, serpentines, and in short, all silicated crystalline stratified rocks, are of neptunean origin, and are not primarily due to metamorphosis or to metasomatosis either of ordinary aqueous sediments or of volcanic materials.

2*d.* The chemical and mechanical conditions under which these rocks were deposited and crystallized, whether in shallow waters, or in abyssal depths (where pressure greatly influences chemical affinities) have not been reproduced to any great extent since the beginning of paleozoic time.

3*d.* The eruptive rocks, or at least a large part of them, are softened and displaced portions of these ancient neptunean rocks, of which they retain many of the mineralogical and lithological characters.

II. The History of Pre-Cambrian Rocks in America.

Coming now to the history of our knowledge of American crystalline rocks, we find that the lithological characters of the Primary gneissic formation of northern New York were known to Maclure in 1817, and were clearly defined in 1832, by Eaton, who, under the name of the Macomb Mountains, described what have since been called the Adirondacks, and moreover distinguished them from the Primary rocks of New England. Emmons, in 1842, added much to our lithological knowledge of the crystalline rocks of northern New York, but regarded the gneisses, with their associated limestones, serpentines and iron-ores, as all of plutonic origin. Nuttall, who had previously studied the similar rocks in the Highlands of southern New York and New Jersey, had, however, maintained, as early as 1822, that these had resulted from an alteration of the adjacent paleozoic graywackes and limestones, into which he supposed them to graduate. This view was, at the time, opposed by Vanuxem and Keating, but was again set forth in 1843, by Mather, who, while admitting the existence of an older or Primary series of crystalline rocks, conceived a great part of these rocks in southern New York to be altered paleozoic, and distinguished them as Metamorphic rocks. To this latter class he referred all the crystalline stratified rocks of New England, and ended by doubting whether a great part of what he had described as Primary was not to be included in his Metamorphic class. The subsequent labors of Kitchell and of Cooke

have however clearly established the views of Vanuxem and Keating as to the Primary age alike of the gneisses and the crystalline limestones of the Highlands.

The similar gneissic series in Canada, which was known to Bigsby and to Eaton as an extension of that of northern New York, was noticed by Murray in 1843, and by Logan in 1847, as pre-paleozoic, though apparently of sedimentary origin, and hence, according to them, entitled to be called Metamorphic rather than Primary. It was described by Logan in 1847, as consisting of a lower group of hornblendic gneisses, without limestones, and an upper group of similar gneisses, distinguished by interstratified crystalline limestones.

These rocks were found by Logan and by Murray to be overlaid both on Lake Superior and in the valley of the upper Ottawa by a series consisting of chloritic and epidotic schists, with bedded greenstones, and with conglomerates holding pebbles derived from the ancient gneiss below. The same overlying series had, as early as 1824, been described by Bigsby on Lake Superior, and by him distinguished from the Primary and classed with Transition rocks.

Labradoritic and hypersthenic rocks like those previously described by Emmons in the Primary region of northern New York, were, in 1853 and 1854, discovered and carefully studied in the Laurentide hills to the north of Montreal, when they were described as being gneissoid in structure, and as interstratified with true gneisses and with crystalline limestones. In 1854, the writer, in concert with Logan, proposed for the ancient crystalline rocks of the Laurentide Mountains, including the lower and upper gneissic groups already mentioned, and the succeeding labradoritic rocks (but excluding the chloritic and greenstone series), the name of Laurentian. In an essay by the writer, in 1855, the oldest gneisses of Scotland and of Scandinavia, were, on lithological and on stratigraphical grounds, referred to the Laurentian series, and at the same time the name of Huronian was proposed for the chloritic and greenstone series, which had been shown to overlie unconformably the Laurentian in Canada.

Previous to this, in 1851, Foster and Whitney had described the Laurentian and Huronian rocks of Lake Superior as constituting one Azoic system of Metamorphic rocks, with granites, porphyries and iron-ores, of igneous origin; and in 1857, Whitney attacked the two-fold division adopted by the Canadian geological survey, maintaining that the stratified crystalline rocks of the region belong to a single series, with a granitic nucleus. The observations of Kimball in 1865, and the later studies of Credner, of Brooks and Pumpelly, and of Irving, have, however, all confirmed the views of the Canadian survey

as to the relations of the Laurentian and Huronian in this region.

The Primary age of the Highlands of southern New York, and their extension in what is called the South Mountain, as far as the Schuylkill, was now unquestioned, but the crystalline rocks to the east of this range, while regarded by Eaton and by Emmons, as also forming a part of the Primary, were, by Mather, as we have already seen, supposed to be altered paleozoic strata. These rocks in New England, with the exception of the quartzites and limestones of the Taconic range, were by him assigned to a horizon above the Trenton limestone of the New York system, and portions of them were conjectured by other geologists, who adopted and extended the views of Mather, to be of Devonian age.

The characteristic crystalline schists of New England and southeastern New York, passing beneath the Mesozoic of New Jersey, re-appear in southeastern Pennsylvania, where they were studied and finally described by H. D. Rogers in 1858. According to him these crystalline schists, while resting unconformably upon an ancient (Hypozoic) gneissic system, were themselves more ancient than the Scolithus-sandstone, which he regarded as the equivalent of the Potsdam. While he supposed these newer crystalline schists, called by him Azoic, to be connected stratigraphically with the base of the Paleozoic series, he nevertheless assigned them to a position below the base of the New York system; thus recognizing in Pennsylvania, below this horizon, two unconformable groups of crystalline rocks, corresponding stratigraphically, as well as lithologically, with the Laurentian and the Huronian of the Lake Superior region.

The existence among these newer crystalline schists of Pennsylvania, of a series distinct from the Huronian, and representing the White Mountain or Montalban rocks (the Philadelphia and Manhattan gneissic group), had not then been recognized. Rogers at this time taught the igneous origin of the magnetic iron-ores, the quartz veins, the serpentines and their associated greenstones in this region. The belief entertained by Rogers of an intimate connection between his upper or Azoic series and the Paleozoic, had its origin apparently in the fact of the existence in this region of still another and a newer crystalline series, the Lower Taconic of Emmons, or the Itacolumite group of Lieber, which I have designated Taconian, and propose to consider in detail in a future paper. In it are included the iron-ores of Reading, Cornwall and Dillsburg, in Pennsylvania.

The views of H. D. Rogers with regard to the crystalline schists of the Atlantic belt were thus, in effect, if not in terms, a return to those held by Eaton and by Emmons, but were in direct opposition to that maintained by Mather, which had been

adopted by Logan, and by the present writer. The belt of micaceous, chloritic, talcose and epidotic schists, with greenstones and serpentines, the extension of a part of the Azoic of Rogers, which, through western New England, is traced into Canada (where it has been known as the Green Mountain range), was previous to 1862, called by the geological survey of Canada, Altered Hudson-River group. It was subsequently referred to the Upper Taconic of Emmons, to which Logan, at that date, gave the name of the Quebec group, assigning it, as had long before been done by Emmons (in 1846) to a horizon between the Potsdam and the Trenton of the New York system.

In 1862 and 1863 appeared, independently, two important papers bearing on the question before us as to the age of these rocks. The first of these, was by Thomas Macfarlane, who, after a personal examination of the three regions, compared the Huronian of Lake Huron and the Green Mountain range of Canada, with portions of the Urschiefer or Primitive schists which, in Norway, intervene between the ancient gneisses and the oldest Paleozoic (Lower Cambrian) strata. The second paper was by Bigsby, who was, as we have seen, the earliest student of the Huronian in the northwest, pointing out that these rocks could not in any sense be called Cambrian, but were the equivalents of the Norwegian Urschiefer. The conclusions of Macfarlane were noticed in connection with the views of Keilhau on these rocks of Norway in "The Geology of Canada" in 1863, with farther comparisons between the New England crystalline schists and the Huronian, but official reasons then, and for some years after, prevented the writer from expressing any dissent from the views of the director of the geological survey of Canada.

Meanwhile, the existence of an equivalent series of crystalline schists was being made known in southern New Brunswick, where they were described by G. F. Matthews in 1863, under the name of the Coldbrook group, which included a lower and an upper division. In a joint report of Matthews and Bailey in 1865, these rocks were declared to be overlaid unconformably by the slates in which Hartt had made known a Lower Cambrian (Menevian) fauna, and were compared with the Huronian of Canada. The lower division of the Coldbrook was then described as including a large amount of pink feldspathic quartzite and of bluish and reddish porphyritic slates. In the same report was described, under the name of the Bloomsbury group, a series lithologically similar to the Coldbrook, but apparently resting on the Menevian, and overlaid by fossiliferous Upper Devonian beds, into which it was supposed to graduate. The Bloomsbury group was therefore regarded as altered Upper Devonian, and its similarity to the pre-Cambrian Cold-

brook was explained by supposing both groups to consist in large part of volcanic rocks.

In 1869 and 1870, however, the writer, in company with the gentlemen just named, devoted many weeks to a careful study of these rocks in southern New Brunswick, when it was made apparent that the Bloomsbury group was but a repetition of the Coldbrook on the opposite side of a closely folded synclinal holding Menevian sediments. These two areas of pre-Cambrian rocks were accordingly described by Messrs. Matthews and Bailey in their report to the geological survey of Canada in 1871, as Huronian, in which were also included the similar crystalline rocks belonging to two other areas, which had been previously described by the same observers under the names of the Kingston and Coastal groups, and by them regarded as respectively altered Silurian and Devonian.

After studying the Huronian rocks in southern New Brunswick, and their continuation along the eastern coast of New England, especially in Massachusetts (where, also, they are overlaid by Menevian sediments), the writer in 1870, announced his conclusion that the crystalline schists of these regions are lithologically and stratigraphically equivalent to those of the Green Mountain range of western New England and eastern Canada. These, he further declared, in 1871, to be a prolongation of the newer crystalline or Azoic schists of Rogers in Pennsylvania, and the equivalents of the Huronian of the northwest. The pre-Cambrian age of these crystalline schists in eastern Canada has now been clearly proved by the presence of their fragments in the fossiliferous Cambrian strata in many localities along the northwestern border of the Green Mountain belt, and farther by the recent stratigraphical studies of Selwyn, as announced by him in 1878.

In close association with these Huronian strata in eastern Massachusetts is found a great development of petrosilex rocks, generally either jaspery or porphyritic in character, and sometimes fissile, which, by Edward Hitchcock were regarded as igneous. These were found to be identical with the rocks designated by Matthews and Bailey, feldspathic quartzites and siliceous and porphyritic slates, which form the chief part of the Lower Coldbrook or inferior division of the Huronian series in New Brunswick. The petrosilexes of Massachusetts were, after careful examination by the writer, described by him in 1870, and in 1871, as indigenous stratified rocks forming a part of the Huronian series. He subsequently, in 1871, studied the similar rocks in southeastern Missouri, and, in 1872, on the north shore of Lake Superior, but was unable to find them in the Green Mountain belt, or in its southward continuation, until, in 1875, he detected them occupying a considerable area

in the South Mountain range in southern Pennsylvania. The stratified petrosilex rocks of all these regions were described in a communication to this Association, in 1876, as apparently corresponding to the *hälleflinta* rocks of Sweden, and, having in view their stratigraphical position both in that country and in New Brunswick, they were then "provisionally referred" "to a position near the base of the Huronian series." Their absence in the Huronian belt in western New England, and in the province of Quebec, as well as at several observed points of contact between the Laurentian and the well-defined Huronian in the northwest, led to the suspicion that these hälleflintas might belong to an intermediate series.

C. H. Hitchcock has pointed out that the characteristic Huronian rocks do not form the higher parts of the Green Mountain range in Vermont, which he conceives to belong to an older gneissic series, a conclusion which the writer regards as premature. Hitchcock, however, in his final report on the geology of New Hampshire, in 1877, adopts the name of Huronian for the crystalline rocks of the Altered Quebec group of Logan, which makes up the chief part of the Green Mountain range in Quebec, is largely developed along it in Vermont, and appears in a parallel range farther east, which extends southward into New Hampshire. In his tabular view of the geognostical groups in this State, Hitchcock assigns to these rocks a thickness of over 12,000 feet, with the name of Upper Huronian; while he designates as Lower Huronian the petrosilex series of eastern Massachusetts, already noticed, where these rocks are of great, though undetermined, thickness. The similar petrosilex or hälleflinta rocks in Wisconsin, where they have lately been described by Irving as Huronian, have, according to this observer, a thickness in a single section, of 3,200 feet. They here sometimes become schistose, and are interbedded with unctuous schists, and rest in apparent conformity upon a great mass of quartzite. The general high inclination both of this series and of the typical Huronian, renders the determination of their thickness difficult. The maximum thickness of the Huronian (excluding the petrosilex series) to the south of Lake Superior, may, according to Major Brooks, exceed 12,000 feet, while the estimates of Credner and Murray, respectively, for this region, and for the north shore of Lake Huron, are 20,000 and 18,000 feet.

As regards the Laurentian, there exists a certain confusion of nomenclature which requires explanation. As originally described, it includes, as already said, a basal granitoid gneiss without limestones, which the writer has elsewhere designated the Ottawa gneiss, and of which the thickness is necessarily uncertain. Succeeding this is the Grenville series of Logan,

having for its base a great mass of crystalline limestone, and consisting in addition to this of gneisses, generally hornblendic, and quartzites, interstratified with similar limestones. To this series, as displayed north of the Ottawa, Logan assigned an aggregate thickness of over 17,000 feet, though the later measurements of Vennor, in the region south of the Ottawa, give to it a much greater volume. The geographical distribution of this limestone-bearing Grenville series gives probability to the suggestion of Vennor that it rests unconformably upon the basal Ottawa gneiss.

These two divisions constitute what was designated by Logan, in his Geological Atlas, in 1865, the Lower Laurentian, the name of Upper Laurentian or Labradorian being then, for the first time given by him to a series supposed to overlie unconformably the former, of which it had hitherto been regarded as constituting a part. This third division has already been referred to as characterized by the predominance of great bodies of gneissoid or granitoid rocks, composed chiefly of labradorite or related anorthic feldspars, and apparently identical with the norites of Scandinavia. With these basic rocks are interstratified crystalline limestones, quartzites and gneisses, all of which resemble those of the Grenville series. This upper group, for which the writer in 1871 proposed the name of Norian, was supposed by Logan to be not less than 10,000 feet thick.

For farther details of the history of these various groups of pre-Cambrian rocks, and their distribution in North America, the reader is referred to a volume published in 1878 by the Second Geological Survey of Pennsylvania, being Part I of the writer's report on Azoic Rocks, intended as an historical introduction to the subject.

III.—The History of Pre-Cambrian Rocks in Great Britain.

In an address before this Association in 1871, in which the writer maintained the Huronian age of a portion of the crystalline schists of New England and Quebec, he further expressed the opinion, based in part upon his examinations at Holyhead in 1867, and in part upon the study of collections in London, that certain crystalline schists in North Wales would be found to belong to the Huronian series. The rocks in question were by Sedgwick, in 1838, separated from the base of the Cambrian, as belonging to an older series, but were subsequently, by Delabeche, Murchison and Ramsay, described and mapped as altered Cambrian strata, with associated intrusive syenites and feldspar-porphyries.

In South Wales, at St. David's in Pembrokeshire, is another area of crystalline rocks, which the geological survey of Great

Britain had mapped as intrusive syenite, granite and felstone (petrosilex-porphyry) having Cambrian strata converted into crystalline schists on one side, and unaltered fossiliferous Cambrian beds on the other. So long ago as 1864, Messrs. Hicks and Salter were led to regard these granitoid and porphyritic rocks as pre-Cambrian, and in 1866 concluded that they were not eruptive but stratified crystalline or metamorphic rocks. After farther study, Hicks, in connection with Harkness, published in 1867, additional proofs of the bedded character of these ancient crystalline rocks, and in 1877 the first named observer announced the conclusion that they belong to two distinct and unconformable series. Of these, the older consisted of the granitoid and porphyritic felstone rocks, and the younger of greenish crystalline schists, the so-called Altered Cambrian of the official geologists; both of these being overlaid by the undoubted Lower Cambrian (Harlech and Menevian) of the region, which holds their ruins in its conglomerates. To the lower of these pre-Cambrian groups, Hicks gave the name of Dimetian, and to the upper that of Pebidian. The last, with a measured thickness of 8000 feet, he supposed to be the equivalent of the Huronian, and compared the Dimetian with the Upper Laurentian of Logan.

The similar crystalline rocks of North Wales, already noticed, were now studied by Professor T. McKenny Hughes of Cambridge, who described them in 1878. These include in Carnarvonshire and Anglesey the greenish crystalline schists which the writer in 1871 referred to the Huronian (pre-Cambrian of Sedgwick, and Altered Cambrian of the geological survey), certain granitoid rocks formerly described as intrusive syenite, and also a reddish feldspar-porphyry which forms two great ridges in Carnarvonshire. This latter was by Professor Sedgwick regarded as intrusive, and is moreover mapped as such by the geological survey, though described in Ramsay's memoir on the geology of North Wales as probably the result of an extreme metamorphism of the lower beds of the Cambrian. The pre-Cambrian age of all these rocks was clearly shown by Hughes, who however considered that the whole might belong to one great stratified series; while Hicks, from an examination of the same region, regarded them as identical with the Dimetian and Pebidian of South Wales.

Dr. Hicks continued his studies in both of these regions in 1878,—being at times accompanied by Dr. Torell of Sweden, Professor Hughes and Mr. Tawney of Cambridge, and the writer—and was led to conclude that beside the chloritic schists and greenstones (diorites) of the Pebidian, and the older granitoid and gneissic rocks, there exists, both in North and South Wales, a third independent and intermediate series,

to which belong the stratified petrosilex or quartziferous porphyries already noticed. These are sometimes wanting at the base of the Pebidian, and at other times form masses some thousands of feet in thickness. At one locality, near St. David's, a great body of breccia or conglomerate, consisting of fragments of the petrosilex united by a crystalline dioritic cement, forms the base of the Pebidian. For this intermediate series, which constitutes the great quartziferous-porphyry ridges of Carnarvonshire, Dr. Hicks and his friends proposed the name of Arvonian, from Arvonia, the Roman name of the region.

This important conclusion was announced by Dr. Hicks at the meeting of the British Association for the Advancement of Science at Dublin, in August, 1878. The writer, previous to attending this meeting, had the good fortune to examine these various pre-Cambrian rocks in parts of Carnarvonshire and Anglesey with Messrs. Hicks, Torell and Tawney. He subsequently, in company with Dr. Hicks, visited the region in South Wales where these older rocks had been studied, and was enabled to satisfy himself of the correctness both of the observations and conclusions of Dr. Hicks, and of the complete parallelism in stratigraphy and in mineral composition between these pre-Cambrian rocks on the two sides of the Atlantic. It may here be mentioned that Dr. Torell, who, during his visit to America in 1876, had an opportunity of studying, with the writer, the petrosilexes of New England and Pennsylvania, which he regarded as identical with the hälleflinta of Sweden, at once recognized them in the Arvonian series of North Wales.

Of the many areas of these various pre-Cambrian rocks which the writer was enabled to examine in company with Dr. Hicks, may be mentioned the granitoid mass of Twt Hill in the town of Carnarvon, and the succeeding Arvonian to Port Dinorwic, followed, across the Menai strait, by the Pebidian on the island of Anglesey, near the Menai bridge. Farther on, the Pebidian was again met with near the railway station of Ty Croes, in the southwest part of the island, succeeded by a large body of Arvonian petrosilex, and a ridge of granitoid gneiss, fragments of which make up a breccia at the base of the Arvonian series. The Pebidian is again well displayed at Holyhead.

In South Wales, the similar rocks were examined by him at St. David's, where three small bands of an impure coarsely crystalline limestone are included in the Dimetian granitoid rock, which is here often exceedingly quartzose. It may be remarked that the Dimetian, as originally defined at this, its first recognized locality, included a great mass of Arvonian

petrosilex, the two forming a ridge which extends for some miles in a northeast direction, flanked by Pebidian rocks, which are sometimes in contact with the one and sometimes with the other series. At Clegyr bridge was seen the base of the Pebidian, already mentioned as consisting of a conglomerate of Arvonian fragments. Another belt of the same crystalline rocks was also visited, a few miles to the eastward of the last, and not far from Haverfordwest, forming, according to Hicks, a ridge several miles in length and about a mile wide. Where seen, at Roch Castle, it was found to consist of Arvonian petrosilex, with some granitoid rock near by. The ridge is flanked on the northwest side by Pebidian and Cambrian, and on the southeast by Silurian strata, let down by a fault.

On the shore of Llyn Padarn, near the foot of Snowdon in North Wales, the porphyritic petrosilex of the Arvonian is again well displayed, while in contact with it, and at the base of the Llanberis (Lower Cambrian) slates, is a conglomerate made up almost wholly of the petrosilex. This locality was supposed by Prof. Ramsay and others to show that the petrosilex is the result of a metamorphosis of the lower portion of the Cambrian, the conglomerates being regarded as beds of passage. The writer, after a careful examination of the locality, agrees with Messrs. Hicks, Hughes and Bonney that there is no ground for such an opinion, but that the conglomerate marks the base of the Cambrian, which here reposes on Arvonian rocks, and is chiefly made up of their ruins. In like manner, according to Prof. Hughes, the Cambrian in other parts of this region includes beds made of the *débris* of adjacent granitoid rocks.

These petrosilex conglomerates of Llyn Padarn are indistinguishable from those found at Marblehead and other localities near Boston, Massachusetts, which have been in like manner interpreted as evidences of the secondary origin of the adjacent petrosilex beds, into which they have been supposed to graduate The writer has, however, always held, in opposition to this view, that these conglomerates are really newer rocks made up of the ruins of the ancient petrosilex. He has found similar petrosilex-conglomerates at various points on the Atlantic coast of New Brunswick, of Lower Cambrian, Silurian and Lower Carboniferous ages, all of which have, in their turn, been by others regarded as formed by the alteration of strata of these geological periods. The evidence now furnished in South Wales of still older (Huronian) beds of petrosilex-conglomerate should be noted by students of North American geology. From observations near Boston, made by one of my former students, I have for some time suspected the existence of petrosilex-conglomerates of pre-Cambrian age.

To the eastward of the localities already mentioned in Wales, are some other small areas of crystalline rocks, including those of the Malverns, and the Wrekin and other hills in Shropshire, all of which appear as islands among Cambrian strata; also those of Charnwood Forest, in Leicestershire, which rise in like manner among Triassic rocks. The Wrekin, regarded by Murchison as a post-Cambrian intrusion, has been shown by Callaway to be unconformably overlaid by Lower Cambrian strata, and consists in part of bedded greenstones, and in part of banded reddish petrosilex-porphyries, closely resembling the Arvonian of North Wales and the corresponding rocks of North America. The geology of Charnwood has within the past two years been carefully studied by Messrs. Hill and Bonney. The ancient rocks of this region are in part crystalline schists (embracing, in the opinion of Dr. Hicks and of the writer—who have seen collections of them—representatives both of the Pebidian and the Arvonian of Wales) and in part eruptive masses, including the granitic rocks of Mount Sorrel.

There is not, so far as known, in the British localities already mentioned, any representative either of the Taconic or Itacolumite group, or of the white micaceous gneisses, with micaceous and hornblendic schists, which I have designated the Montalban series. I have, however, found the latter well displayed in Ireland, in the Dublin and Wicklow Hills. The probable presence both of this series and of the Huronian in the northwest of Ireland was pointed out by me in 1871. I have there lately seen the Huronian on Lough Foyle, and also in Scotland in various parts of Argyleshire and Perthshire, as along the Crinan Canal and in the vicinity of Loch Etive and Loch Awe. From collections sent me by Mr. James Thomson, of Glasgow, it appears that both Huronian and Laurentian rocks occur in the island of Islay.

The crystalline schists of Charnwood offer, as was pointed out by Messrs. Hill and Bonney, many resemblances with parts of the Ardennian series of Dumont in France and Belgium. These, which have been in turn regarded as altered Devonian, Silurian and Lower Cambrian, were, as shown by Gosselet, islands of crystalline rock in the Devonian sea, and in one part include argillites with impressions of *Oldhamia* and an undetermined graptolite. These rocks have lately been described in detail in the admirable memoir of de la Vallée Poussin and Renard. The writer had the good fortune, in 1878, to visit this region, and in company with Gosselet and Renard to examine the section along the valley of the Meuse. The crystalline rocks here displayed greatly resemble those of the American Huronian, in which may be found most of the types described by the authors of the memoir just mentioned. It

would be easy to extend further this review of late advances made in the study of the ancient crystalline rocks, but the writer has preferred to confine himself to those regions which he has lately examined.

Conclusions.

1. The Pebidian of Hicks has both the lithological characters and the stratigraphical position of the Huronian of North America, to which he has already referred it.

2. The Arvonian is, in like manner, identical with the Hälleflinta group of Sweden and with the Petrosilex group of North America, which I had provisionally included in the lower part of the Huronian, and which Hitchcock subsequently called Lower Huronian. The fact that there is in Wales a stratigraphical break between it and the overlying Huronian, will help to explain the frequent absence of the Arvonian at the base of Huronian in many of its American localities.

3. The Dimetian, including the granitoid and gneissic rocks with limestone bands, so far as can be seen in the limited outcrops, is indistinguishable from parts of the Laurentian of North America. It was from a misconception that Dr. Hicks in 1878 provisionally referred the Dimetian to the Upper Laurentian, a name at one time used by the geological survey of Canada to designate the Norian series, which in some parts of North America overlies unconformably the Laurentian. Hicks at the same time designated as Lower Laurentian the gneiss of the Hebrides (Lewisian of Murchison), which he believed to be distinct from and older than the Dimetian. These two apparently correspond to the Ottawa and Grenville divisions of the proper Laurentian in Canada, and perhaps to the Bojian and Hercynian gneisses of Gümbel, in Bavaria.

[The following is a partial list of publications relating to the rocks noticed in part III of this paper:

In the Quar. Jour. Geol. Soc. of London are the following papers on these rocks in Wales: Hicks, May, 1877, p. 230; Hicks & Davies, Feb., 1878, p. 147, and May, 1878, p. 153; Hughes & Bonney, Feb., 1878, p. 137; Hicks & Davies, May, 1879, p. 285; Hicks & Bonney, ibid., p. 295; Bonney, ibid., p. 309; Bonney & Houghton, ibid., p. 821; Hughes, Nov., 1879, p. 682; Maw, Aug., 1878, p. 764; also Hicks, rocks of Ross-shire, Nov., 1878, p. 811. Tawney, Older Rocks of St. Davids: Proc. Bristol Naturalists' Society, vol. ii, part 2, p. 110.

On these rocks in Shropshire, in the same journal, Allport, Aug., 1877, p. 449; Callaway, Nov., 1877, p. 653, and Aug., 1878, p. 754; Callaway & Bonney, Nov., 1879, p. 643.

On these rocks in Charnwood Forest, in the same journal, Hill and Bonney, Nov., 1877, p. 753, and May, 1878, p. 199.

See farther, Hunt, Chemical and Geological Essays, pp. 34, 269, 270, 272, 278, 283; also his Azoic Rocks, part i (Second Geol. Survey of Penn., 1878), pp. 187, 188.

For the rocks of the Ardennes see Memoire sur les Roches dites Plutoniques, etc. (4to, pp. 264), by de la Vallée Poussin and Renard, from Memoires de la

l'Acad. Royale de la Belgique for 1876; and Memoire sur la Comp. Minéralogique du Coticule, by Renard, from the same for 1877. Also Gosselet and Malaise, Terrain Silurian des Ardennes, Bull. Acad. Roy. de la Belgique (2) No. 7, 1868; Dewalque, Terrain Cambrien des Ardennes, Ann. Soc. Géol. de la Belgique, tom. i, p. 63; and farther, Hunt, Chem. and Geol. Essays, p. 270.]

Appendix.

Since the above paper was read the author has received (November, 1879) a private communication from Prof. L. W. Bailey giving his latest results as to the pre-Cambrian rocks of southern New Brunswick, which confirm what has already been said about that region. Bailey separates the Huronian into a lower division, for which he reserves the name of Coldbrook, consisting chiefly of petrosilex rocks, and an upper division, the typical Huronian, called by him the Coastal group. He adds that there is between the two a marked physical break, which is indicated by a stratigraphical discordance, and by the presence in the lower part of the Coastal group of coarse conglomerates made up from the ruins of the Coldbrook or underlying division. This corresponds to the break between the similar Arvonian and Huronian in South Wales.

At the meeting of the British Association for the Advancement of Science at Sheffield in August, 1879, Dr. Hicks read a paper on the Classification of the British Pre-Cambrian Rocks, which is published in the Geological Magazine for October, 1879. He concludes that the Pebidian is "a group of enormous thickness, which is largely distributed over Great Britain, where it has a prevailing strike of N.N.E. and S.S.W., or from this to N.E. and S.W." In addition to the localities which we have already mentioned in Great Britain, he notes its occurrence in Shropshire and in Charnwood Forest, and also in the northwest of Scotland, where, as elsewhere, it enters largely into the Lower Cambrian conglomerates. The group is concisely described by him as consisting "for the most part of chloritic, talcose, feldspathic and micaceous schistose rocks, alternating with slaty and massive greenstones, dolomitic limestones, serpentines, lava-flows, porcellanites, breccias and conglomerates. It is also traversed frequently by dykes of granite, dolerite, etc."

The conglomerates at the base of the Huronian in Wales are largely made up of the masses derived from the Arvonian, with which it "is undoubtedly at most of the points examined, unconformable." This Arvonian series, Hicks regards as identical with the great Hälleflinta group of the Swedish geologists and with the Petrosilex series which the writer has made known in America. In addition to the localities already mentioned of it in the British Isles, Hicks notes its occurrence in

the Harlech Mountains and the Orkneys, and probably also in the Western Islands, and in the Grampians of Scotland. Its strike in the regions examined by him is generally about N. and S.

As regards the gneissic Dimetian group, the strike of which is N.W. and S.E., or from this to N. and S., Hicks adds to the localities in Wales, already noticed, its occurrence in the Malvern chain, especially in the Worcester Beacon, and cites Dr. Callaway as authority for its existence in Shropshire. Hicks further notes its presence at several points in the northwest Highlands of Scotland. From this series of light-colored gneisses, often very quartzose, with limestone bands, he separates, as we have seen, under the name of Lewisian, proposed by Murchison for the ancient gneisses of Lewis and others of the Hebrides Isles, these, and similar reddish and dark-colored hornblendic gneisses which are found in parts of the Malvern chain, in the northwest of Ireland, and possibly also in Anglesey. This series, according to Hicks, is unconformably overlaid by the Dimetian, brecciated beds which hold fragments of the older Lewisian gneiss. The strike in these older gneisses "is usually E. and W., or some point between that and N.W. and S.E."

Dr. Hicks concludes the above paper by remarking that the chief part of these ancient rocks in Great Britain "were until recently supposed to be either intrusive masses, or altered sediments belonging to tolerably recent times," and adds, "it is becoming more and more an acknowledged fact that the metamorphism of great groups of rocks does not take place so readily as was formerly supposed, but that some special conditions, such as do not appear to have prevailed over this area since pre-Cambrian times, were necessary to produce so great a result."

The reader in this connection is referred to the abstract of a memoir communicated by the writer to the British Association at Dublin in August, 1878, on The Origin and the Succession of the Crystalline Rocks of North America, which will be found in the Geological Magazine for that year (page 466), as well as in Nature, vol. xviii, page 443.

Montreal, February, 1880.

ART. XXXIV. — *Synopsis of the Cephalopoda of the North-eastern Coast of America;* by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLVI. With Plates XII to XVI.

THE recent increase in the number of Cephalopods known to belong to this fauna is remarkable. Up to the year 1871, only three species were recorded. In 1872, an undetermined *Rossia* and *Octopus Bairdii* V. were discovered. Since that time fourteen additional species have been added, mostly by the writer, so that, at the present time, *eighteen species* are known from this coast. Four of these have been first discovered by the dredgings carried on by the U. S. Fish Commission, in charge of the writer. Six have been brought in by the Gloucester fishermen, from the Bank fisheries, among their valuable contributions to the collections of the U. S. Fish Commission and National Museum.

ARCHITEUTHIS.

In several former articles in this Journal,* the writer has recorded the occurrence of fourteen† American examples of the gigantic squids belonging to this genus, and apparently representing two species. Since the last of these notices, eight additional specimens have been found on the coasts of Newfoundland and Nova Scotia. In a somewhat extended article on the large cephalopods, recently published,‡ the author has given all the available facts in relation to the later discoveries, and has redescribed, in much greater detail than before, and with numerous illustrations, the various specimens formerly noticed, of which portions, more or less important, have been preserved. In the present article, the recent specimens are enumerated in order to complete the series of notices for this Journal. Since the capture of the fine specimen of *A. princeps*, at Catalina Bay, in 1877 (our No. 14, see Plate XII), which was preserved nearly entire in the New York Aquarium, the following have been recorded:

No. 15.—*Hammer Cove specimen*, 1876.

In a letter from Rev. M. Harvey, dated Aug. 25, 1877, he states that a big squid was cast ashore Nov. 20, 1876, at Ham-

* This Journal, vol. vii, p. 158, Feb., 1874; vol. ix, pp. 123, 177, Plates II–V, 1875; vol. x, p. 213, Sept., 1875; vol. xii, p. 236, 1876; vol. xiv, p. 425, Nov., 1877. Also, American Naturalist, vol. viii, p. 167, 1874; vol. ix, pp. 21, 78, Jan. and Feb., 1875.

† Of these, No. 6 proved to be the same as No. 3, and should be cancelled.

‡ Transac. Connecticut Acad., vol. v, pp. 177–258, Dec., 1879, to Feb., 1880, Plates XIII to XXV.

mer Cove, on the southwest arm of Green Bay, in Notre Dame Bay, Newfoundland. When first discovered by his informant it had already been partially devoured by foxes and sea-birds. Of the body, a portion 5 feet long remained, with about 2 feet of the basal part of the arms. The head was 18 inches broad; tail, 18 inches broad; eye-sockets, 7 by 9 inches; stump of one of the arms, 3·5 inches in diameter.

No. 16.—*Lance Cove specimen*, 1877 (*Architeuthis princeps?*).

In a letter dated Nov. 27, 1877, Mr. Harvey gives an account of another specimen, which was stranded on the shore at Lance Cove, Smith's Sound, Trinity Bay, about twenty miles farther up the bay than the locality of the Catalina Bay specimen (No. 14). He received his information from Mr. John Duffet, a resident of the locality, who was one of the persons who found and measured it. His account is as follows: "On Nov. 21, 1877, early in the morning, a 'big squid' was seen on the beach, at Lance Cove, still alive and struggling desperately to escape. It had been borne in by a 'spring tide' and a high inshore wind. In its struggles to get off it ploughed up a trench or furrow about thirty feet long and of considerable depth by the stream of water that it ejected with great force from its siphon. When the tide receded it died. Mr. Duffet measured it carefully, and found that the body was nearly 11 feet long (probably including the head); the tentacular arms, 33 feet long. He did not measure the short arms, but estimated them at 13 feet, and that they were much thicker than a man's thigh at their bases. The people cut the body open and it was left on the beach. It is an out-of-the-way place, and no one knew that it was of any value. Otherwise it could easily have been brought to St. John's, with only the eyes destroyed and the body opened." It was subsequently carried off by the tide, and no portion was secured.

No. 17.—*Trinity Bay specimen*, 1877.

Mr. Harvey also states that he had been informed by Mr. Duffet that another very large 'big squid' was cast ashore in October, 1877, about five miles farther up Trinity Bay than the last. It was cut up and used for manure. No portions are known to be preserved, and no measurements were given.

No. 18.—*Thimble Tickle specimen*, 1878. *Architeuthis princeps* (*?*).

The capture of this specimen has been described by Mr. Harvey, in a letter to the Boston Traveller, Jan. 30, 1879:

"On the 2d day of November last, Stephen Sherring, a fisherman residing in Thimble Tickle [near Little Bay Copper Mine, Notre Dame Bay], not far from the locality where the

other devil-fish [No. 19] was cast ashore, was out in a boat with two other men; not far from shore they observed some bulky object, and, supposing it might be part of a wreck, they rowed toward it, and, to their horror, found themselves close to a huge fish, having large glassy eyes, which was making desperate efforts to escape, and churning the water into foam by the motion of its immense arms and tail. It was aground and the tide was ebbing. From the funnel at the back of its head it was ejecting large volumes of water, this being its method of moving backward, the force of the stream, by the reaction of the surrounding medium, driving it in the required direction. At times the water from the siphon was black as ink.

"Finding the monster partially disabled, the fishermen plucked up courage and ventured near enough to throw the grapnel of their boat, the sharp flukes of which, having barbed points, sunk into the soft body. To the grapnel they had attached a stout rope, which they had carried ashore and tied to a tree, so as to prevent the fish from going out with the tide. It was a happy thought, for the devil-fish found himself effectually moored to the shore. His struggles were terrific as he flung his ten arms about in dying agony. The fishermen took care to keep a respectful distance from the long tentacles, which ever and anon darted out like great tongues from the central mass. At length it became exhausted, and as the water receded it expired."

The body measured 20 feet from the beak to the extremity of the tail. The circumference of the body is not stated, but one of the tentacular arms measured 35 feet in length.

According to these measurements, this was the largest specimen yet found, it being nearly twice as large as No. 14.

No. 19.—*Three Arms specimen*, 1878. *Architeuthis princeps* (?).

Mr. Harvey has also given an account of this specimen, in the same letter to the Boston Traveller, referred to under No. 18. This one was found cast ashore after a heavy gale of wind, Dec. 2, 1878, by Mr. William Budgell, a fisherman residing at Three Arms, South Arm of Notre Dame Bay, near Little Bay mines. It was dead when found, and was cut up and used for dog-meat. Mr. Harvey's account is as follows:

"My informant, a very intelligent person, who was on a visit in that quarter on business, arrived at Budgell's house soon after he had brought it home in a mutilated state, and carefully measured some portions with his own hand. He found that the body measured 15 feet from the beak to the end of the tail. * * * * * * The circumference of the body at its thickest part was 12 feet. He found only one of the short arms perfect, which was 16 feet in length, being five feet longer

than a similar arm of the New York specimen [No. 14], and he describes it as thicker than a man's thigh."

No. 20.—*Banquereau specimen*, 1879.

This consists of the terminal part of a tentacular arm, which was taken by Capt. J. W. Collins and crew, of the schooner "Marion," from the stomach of a large and voracious fish (*Alepidosaurus ferox*), together with the only specimen hitherto discovered of the remarkable squid, *Histioteuthis Collinsii* V. The fish was taken on a halibut trawl-line, N. lat. 42° 49′; W. long. 62° 57′, off Nova Scotia, Jan., 1879. This fragment, after preservation in strong alcohol, now measures 18 inches in length. It includes all the terminal club, and a small portion of the naked arm below it.

No. 22.—*Brigus specimen*, 1879.

Mr. Harvey states that portions of another large squid were cast ashore near Brigus, Conception Bay, in October, 1879.

Two of the short arms, each measuring eight feet in length, were found, with other mutilated parts, after a storm.

No. 23.—*James's Cove specimen*, 1879.

From Mr. Harvey I have also recently received an account of another specimen, which was captured entire about the first of November last, at James's Cove, Bonavista Bay, N. F.

"Mr. Thomas Moores and several others saw something moving about in the water, not far from the stage. Getting into a punt, they went alongside, when they were surprised to see a monster squid. One of the men struck at it with an oar, and it immediately struck for the shore, and went quite upon the beach. The men then succeeded in getting a rope around it, and hauled it quite ashore. It measured 38 feet altogether. The body was about 9 feet in length, and two of its tentacles or horns were 29 feet each. There were several other smaller horns, but they were not so long. The body was about 6 feet in circumference."

This seems to have been a fine and complete specimen, about the size of the Catalina Bay specimen (No. 14). Unfortunately the fishermen, as usual, immediately destroyed it, and probably no portion was preserved.

Architeuthis Harveyi Verrill. (Harvey's giant squid).

Trans. Conn. Acad., v, p. 197, Plates xiii to xvia, Dec., 1879.
Megaloteuthis harveyi Kent, Proc. Zool. Soc. London, 1874, p. 178.
Architeuthis monachus Verrill, this Journal, vol. ix, pp. 124, 177, Pl. ii, iii, iv, 1875; vol. xii, p. 236, 1876; American Naturalist, vol. ix, pp. 22, 78, figs. 1–6, 10, 1875 (? *non* Steenstrup).
Ommastrephes harveyi Kent, Proc. Zool. Soc. London, 1874, p. 492.

PLATE XIII.

The principal diagnostic characters of this species, so far as determined, are as follows: Sessile arms unequal in size, nearly equal in length, decidedly shorter than the head and body together, and scarcely as long as the body alone. Tentacular arms, in extension, about four times as long as the short arms: about three times as long as the head and body together. Caudal fin small, less than one-third the length of the mantle, sagittate in form, with the lateral lobes extending forward much beyond their insertions; the posterior end tapering to a long acute tip. Jaws with a smaller notch and lobe than in *A. princeps*. Suckers of the sessile arms (so far as seen) mostly with numerous acute teeth all around the circumference, all similar in shape, but those on the inner margin smaller than those on the outer, and sometimes obsolete in certain suckers. Sexual characters are not yet determined.

Architeuthis princeps Verrill. (Giant squid).

Architeuthis princeps Verrill, this Journal, vol. ix, pp. 124, 181, Plate v, 1875; American Naturalist, vol. ix, pp. 22, 79, figs. 25–27, 1875; Trans. Conn. Acad., v. pp. 210 to 217, Plates xvii to xx, Jan. and Feb., 1880.

Ommastrephes (*Architeuthis*) *princeps* Tryon, Manual of Conchology, p. 185, Pl. 85, 1879, (figures copied and descriptions compiled from papers cited).

PLATE XII.

This species is distinguished from the preceding by the length and inequality of the short arms, of which the longest (ventral or subventral) exceed the combined length of the head and body by about one-sixth; by the denticulation of the suckers of the short arms, of which there are two principal forms, some having very oblique horny rings, with the outer edge very strongly toothed with broad, flat, acuminate teeth, and the inner edge slightly or imperfectly denticulated; the others having less oblique rings, with the acuminate denticles similar in form all around, though smaller on the inner margin; by the stronger jaws, which have a deeper notch and a more elevated tooth on the anterior edge; and by the caudal fin, which is short-sagittate in form, with the posterior end less elongated than in the preceding species.

Sthenoteuthis megaptera Verrill. (Broad-finned large squid).

Trans. Conn. Acad., v. p. 223, Pl. xxi, figs. 1–9, Feb., 1880.

Architeuthis megaptera Verrill, this Journal, vol. xvi, p. 207, 1878. Tryon, Manual of Conchology, vol. i, p. 187 (description copied from preceding paper).

The original specimen was found thrown ashore near Cape Sable, N. S. To this species is doubtfully referred a beak, taken on Sable I. Bank, in 280–300 fathoms, by Capt. Geo. A. Johnson and crew, of the schooner "A. H. Johnson."

The genus *Sthenoteuthis*, established to receive this species, differs from *Ommastrephes*, to which it is closely allied, in having, like *Architeuthis*, numerous small, smooth-rimmed suckers alternating with tubercles, on the proximal part of the 'club,' for the mutual adhesion of the long tentacular arms. The lateral arms are provided with very broad, thin marginal membranes. The caudal fin is very broad. Besides the type it also includes *S. Bartramii* (*Loligo Bartramii* Les.) from the Gulf Stream region, and probably *S. pteropus* (Steenst. sp.) from the Mediterranean and Bermuda.*

Ommastrephes illecebrosa Verrill. (Short-finned squid).

Loligo illecebrosa Lesueur, Journ. Phil. Acad. Nat. Sci., ii, p. 95, Plate x, figs. 18–21 (incorrect figures). Gould, Invert. Mass., ed. I, p. 318, 1841.

Ommastrephes sagittatus (pars) D'Orbig., Céph. Acétab., p. 345, Plate 7, fig. 1, (after Lesueur). Binney, in Gould's Invert. Mass., ed. II, p. 510, 1870 (excl. syn.), Plate xxvi, fig. 341–4 [341 is imperfect], *not* Plate xxv, fig. 339. Tryon (pars) Man. Conch., I, p. 177, Pl. 78, fig. 342 (very bad, after Lesueur), Pl. 79, fig. 343, 1879 (*not* Plate 78, figs. 341, 345).

Ommastrephes illecebrosa Verrill, this Journal, vol. iii, p. 281, 1872; Report on Invert. Viney. Sd., etc., 1873, pp. 441, 634.

Long Island Sound (Verrill) to Cumberland Gulf (Kumlein). Abundant from Cape Cod to Newfoundland. Saybrook, Conn. (U. S. Fish Com.) Vineyard Sd., Mass., large in winter, small in May (V. N. Edwards).

The Mediterranean form, usually identified with the *var. b*, of *Loligo sagittata* Lamarck, 1799,† is closely related to our species, but if the published figures and descriptions can be relied upon, it can hardly be identical. The American form has a more elongated body, with a differently shaped caudal fin, which is relatively shorter than *O. sagittatus*, as given by European authors. The figure given by Verany is, however, an exception in this respect, for in that the body is represented about as long as in some of our larger specimens.‡

Of our species, I have measured large numbers of specimens, preserved in different ways, and also fresh, and have found no great variation in the form and relative length of the caudal fin, among specimens of similar size, nor do the sexes differ

* A specimen from Bermuda is described in detail in Trans. Conn. Acad., vol. v, p. 228, but it lacked the 'clubs.'

† It seems more probable, however, that Lamarck's description applied, in part, to *O. Bartramii* (Les. sp.) of the Gulf Stream region. Blainville thus applied it.

‡ It should be remarked, however, that Lesueur's figure of *O. illecebrosa* shows the body too small and short in proportion to the size of the fin, and the fin wrong in shape, and occupying more than half the length of the mantle; the proportions of the arms are also erroneous. But Lesueur explains these defects by his statement that the figures were hasty sketches made for the sake of preserving the colors, and that he saved a specimen by which to correct afterwards his drawings and description, but the specimen saved turned out to be *L. pavo*, so that the original sketches were published without correction. Tryon's figure 342 is a reduced copy of one of Lesueur's, though not so credited.

in this respect. The two sexes are probably equally numerous, but in our collections the males usually predominate, and the largest specimens are usually males, though equally large females do occur. In 31 measured specimens, in alcohol, from various localities, and of both sexes, the average length from tip of tail to dorsal edge of the mantle was 6·96 inches; from tip of tail to insertion of fin, 2·59; average proportion of fin to mantle-length, 1 : 2·68. Among these the proportions varied from as low as 1 : 2·50, in some of the larger ones, (with mantle above 8 inches), up to 1 : 2·85, in the smaller ones, (with the mantle about 4 inches long). The caudal fin is about one-third broader than long, and its breadth is usually rather less than half the length of the mantle. In fresh specimens the tentacles can extend back beyond the base of the caudal fin. The portion of the tentacles bearing suckers is always less than half the whole length. The relative size of the suckers varies greatly in both sexes, perhaps in connection with the renewal of their horny rings, periodically.

In the *male* of our species the left ventral arm is strongly hectocotylized, nearly as in *Loligo*. Toward the tip the suckers of the outer row, for some distance, have their pedicels larger and longer, with swollen bases, while the suckers themselves gradually become smaller till they nearly or quite disappear, and then, close to the tip, they again become normal.

Taonius pavo Steenstrup. (Peacock squid).

Loligo pavo Lesueur, Journal Acad. Nat. Science Phila., ii, p. 96, Plate, 1821.
Loligopsis pavo Ferussac and D'Orb., Céph. Acét., p. 321, Pl. 4, figs. 1–8, (after Lesueur). Binney, in Gould, Invert. Mass., ed. II, p. 309, (but *not* the figure, Pl. xxvi). Tryon, Man. Conch., i, p. 163, Pl. 68, fig. 252, Pl. 69, fig. 253, 1879, (figures copied from Lesueur and D'Orb.).
Taonius pavo Steenst., Oversigt Kgl. Danske Vidensk. Selsk. Forh., 1861, pp. 70 and 85.

Sandy Bay, Mass. (Lesueur). Newfoundland (Steenstrup). No instance of the occurrence of this oceanic species on the New England coast has been recorded since the original specimen was described by Lesueur, in 1821.

Taonius hyperboreus Steenstrup. (Goggle-eyed squid).

Leachia hyperboreus Steenstrup, Kongelige Danske Vidensk. Selsk. Skrifter, 5te Række, iv, p. 200, 1856, (sep. copies, p. 16).
Taonius hyperboreus Steenst., Oversigt Kgl. Danske Vidensk. Selsk., Forhandlinger, 1861, p. 83. Verrill, this Journal, xvii, p. 243, 1879.
Loligopsis hyperboreus Tryon, op. cit., p. 162, (inaccurate translation, after Steenstrup).

Near the northern edge of the Gulf Stream, W. long. 55°, Jan., 1879 (Thomas Lee). Greenland (Steenstrup).

Histioteuthis Collinsii Verrill. (Webbed squid).

This Journal, xvii, p. 241, March, 1879. Tryon, op. cit., i, p. 166, 1879, (copied from preceding). Verrill, Trans. Conn. Acad., v, p. 234, Plates xxii and xxvi. Feb., 1879.

PLATE XIV.

The only specimen known was obtained from the stomach of a large fish (*Alepidosaurus ferox*), taken by Capt. J. W. Collins and crew of the schooner "Marion," in deep water off Nova Scotia, N. lat. 42° 49′; W. long. 62° 57′.

Rossia Hyatti Verrill. (Hyatt's bob-tailed squid).

This Journal, vol. xvi, p. 208, Sept., 1878. Tryon, Man. Conch., i, p. 166, 1879, (description compiled from preceding).

PLATE XV, figures 1 and 2.

This species has been taken in numerous localities, by the dredging parties of the U. S. Fish Commission, in 1877, 1878 and 1879, off Cape Cod; in Mass. Bay; off Cape Ann, in the Gulf of Maine; off Cape Sable, N. S.; and off Halifax, N. S. It occurs in 40 to 150 fathoms. Its relatively large eggs are laid in small clusters in the large oscules or cavities of several species of sponges. It has also been received through the Gloucester halibut fishermen, from the Banks, off Nova Scotia.

This species has a strong general resemblance to *R. glaucopis* Lovén, as figured in the admirable work of G. O. Sars, but the latter has shorter lateral arms, and the suckers of the sessile arms are in two rows, while they are four-rowed in our species.

Rossia sublevis Verrill. (Smooth bob-tailed squid).

Rossia sublævis Verrill, this Journal, xvi, p. 209, 1878. Tryon, Man. Conch., i, p. 160, 1879, (description compiled from preceding).

PLATE XV, figure 3.

Taken by the dredging parties of the U. S. Fish Commission in the trawl-net, at numerous localities, in 1877, 1878 and 1879, in 50 to 140 fathoms, off Mass. Bay; in Mass. Bay; off Cape Cod; off Cape Sable, N. S.; and off Halifax. Also recently brought in by the Bank fishermen, of Gloucester.

Sepiola leucoptera Verrill. (Butterfly squid).

Sepiola leucoptera Verrill, this Journal, vol. xvi, p. 378, 1878. Tryon, Man. Conch., i, p. 158, 1879, (description copied from preceding, with remarks.)

PLATE XV, figures 4 and 5.

Three specimens were taken by the U. S. Fish Com., in the trawl-net, 30 miles east from Cape Ann, Mass., 110 fathoms, August, 1878. One specimen was taken off Cape Cod, 123 fathoms, with the bottom temperature 41° F., August, 1879.

The last named specimen, (Plate xv, fig. 5) when fresh was about 31^{mm} long, exclusive of the arms. In this the head, above, in front of the eyes, was white; back and the base of the fins thickly spotted with brown; posterior part of the back with an emerald-green iridescence. Sides of the body, below the fins, and posterior end of the body, silvery white. A large shield-shaped

ventral area of brown, with a bright blue iridescence, and bordered with a band of brilliant blue, occupies most of the lower surface. Fins transparent, whitish, except at base. Lower side of head, siphon and outer bases of arms, light brown. Eyes blue above, green below. The fins are large, nearly as long as the body.

Loligo Pealei Lesueur. (Long-finned squid.)

Journ. Acad. Nat. Sci. Philad., vol. ii, p, 92, Plate 8, 1821.
Férussac and D'Orbigny, Céph. Acét., p. 311, Pl. xi, figs. 1–5, Pl. xx, figs. 17–21. Binney in Gould's Invert. Mass., ed. 2, p. 514, Pl. 25, fig. 340, (figure erroneously referred to *O. Bartramii*). Verrill, Report on Invert. Vineyard Sd., pp. 440, 635 (sep. copies, p. 341), Pl. xx, figs. 102–105, 1877. Tryon, Man. Conch., I, p. 142, Pl. 51, figs. 134–140, (figs. from Fér. and D'Orb.)
Loligo punctata Dekay, Nat. Hist. N. Y., Mollusca, p. 3, Pl. 1, fig. 1, 1843. (young.)

South Carolina to Massachusetts Bay.

This is the *common squid* from Cape Hatteras to Cape Cod. In Long Island Sound and Vineyard Sound it is very abundant, and is taken in large numbers in the fish-pounds and seines. It is comparatively scarce north of Cape Cod. Large specimens were taken in the pounds at Provincetown, Mass., August, 1879. As in all other squids, the length of the caudal fin, in proportion to that of the body (mantle), increases with age, even after maturity. For this species, in specimens having the mantle from 4 to 5 inches long, the ratio of the fin to the mantle usually varies from 1 : 1·80 to 1:1·90; with the mantle 6 to 7 inches long, the ratio usually becomes 1:1·65 to 1:1·75; in the largest specimens, with the mantle 10 to 13 inches long, the ratio varies from 1 : 1·56 to 1 : 1·70. This variation is independent of sex, and is due mostly to the ordinary changes by growth. The ratio of the breadth of the caudal fin to the length of the mantle, in the larger specimens, ranges from 1:2·15 to 1:2·40, varying considerably according to the mode of preservation. The suckers in the two central rows of the tentacular club, are large and remarkably high; the rim is closely and sharply denticulated, one or three minute denticles alternating with the larger ones.

Var. borealis Verrill. Four specimens, taken in 1878, at Annisquam, Mass., on the north side of Cape Ann, and sent to me by Professor A. Hyatt, differ so decidedly from the typical ones that it seems desirable to give the form a distinctive name, as a variety or geographical race. Two are females, filled with eggs. When a larger series can be examined it may even prove to be a distinct species. They have the general form and appearance of the pale-colored *L. Pealei*, with the caudal fin broader than usual. Ratio of fin-length to mantle, 1 : 1·62; of fin-width to mantle-length, 1 : 1·82. Length of mantle, above, in one female, 7·30 inches; of caudal fin, 4·5; to end of longest sessile

arms, 10·7. The anterior dorsal lobe of the mantle-edge is larger and longer than usual, and the 'pen,' while having the general form of that of *L. Pealei*, tapers more gradually anteriorly, and has a narrower, more tapered, more acute and stiffer anterior tip. But the most obvious peculiarity is the unusual smallness of the suckers, both of the tentacles and short arms, which are little more than half as large as those of typical *L. Pealei* of the same size. The largest of the median suckers of the tentacular club are only 2^{mm} in diameter of aperture; the largest of those on the 3d pair of arms, $1{\cdot}5^{mm}$. The rims of the suckers are white, and their denticulation is similar to that of the typical form, but finer.

Loligo pallida Verrill. (Pale long-finned squid).

Report on Invert. Viney. Sd., in Rep. U. S. Com. Fish and Fisheries, i, p. 635, [341], Pl. xx, figs. 101, 101a, 1873. Tryon, op. cit. p. 143, Pl. 52, figs. 141, 142, (des. and figs. copied from preceding).

This is closely allied to *L. Pealei*, and may finally prove to be only a geographical variety of it, but among the very numerous specimens, of both forms, that I have already examined, I have not found intermediate ones. The principal differences are the larger and flatter median suckers of the tentacular clubs, which also have darker colored and more strongly denticulate rims; the larger suckers of the sessile arms; a stouter body in both sexes; a larger and broader caudal fin, the ratio of the breadth of the fin to the mantle-length, in the larger specimens (with mantle 7 to 9 inches long), being from 1 : 1·80 to 1 : 1·95, while in *L. Pealei*, of corresponding size, the ratio is 1 : 2·15 to 1 : 2·30.

This form has been received, hitherto, only from the western part of Long Island Sound, where it is abundant, with the schools of *menhaden*.

Parasira catenulata Steenstrup.

Octopus tuberculatus Risso (?), Hist. nat. de l'Eur. merid., iv, p. 3, 1826 (t. D'Orbig.)
Octopus catenulatus Férussac, Poulpes, Pl. vi, bis, ter., 1828 (t. D'Orbig.)
Philonexis tuberculatus Fér. and D'Orbig., Céph. Acét., p. 87, Pl. vi, bis, ter.

A fine specimen of this interesting species was taken in Vineyard Sound, Mass., by Mr. V. N. Edwards, in 1876.* It was not known previously from the American coast, and has been regarded as peculiar to the Mediterranean. The total length of this specimen is 8 inches; of mantle, 2; circumference of body, 6; length of dorsal arms, from eye, 5·4; of second pair, 3·7; of third pair, 3·30; of fourth pair, 5·30. Color, above, deep violet; beneath, yellowish. The remark-

*This is the same specimen that was referred to under *Octopus granulatus*, in this Journal, xvi, p. 210, 1878. The specimen had been mislaid, and at that time was not to be found. It was recorded from memory, and only an imperfect examination of it had been made when received.

able tubercles of the ventral surface, mostly have five ridges converging to each, rarely six. In all other respects it agrees with the figures of Férussac and D'Orbigny. According to Targioni-Tozzetti, *P. catenulata* is distinct from *P. tuberculata.* If so, our species should bear the former name.

Octopus Bairdii Verrill. (Baird's Octopus.)

This Journal, vol. v, p. 5, Jan., 1873; American Naturalist, vol. vii. p. 394, figs. 76, 77, 1873; Amer. Assoc. for Adv. Sci. for 1876, p. 348, Pl. 1, figs. 1, 2, 1874. G. O. Sars, Mollusca Regionis Arcticæ Norvegiæ, p. 339, Pl. 33, figs. 1 to 10, (♀) Pl. xvii, figs. 8^a to 8^d (dentition and jaws). 1878. Tryon, Man. Conch., i, p. 116, Pl. 32, figs. 37, 38 (description and figures from the papers by A. E. V.)

In addition to the localities previously given, this species has been taken in numerous localities off the coasts of Massachusetts and Nova Scotia, by the dredging parties of the U. S. Fish Commission, in 1877, '78 and '79. It is common in 50 to 150 fathoms, both on muddy and on hard bottom. Both sexes occur, the females less frequently. The sexes show but little difference, except the hectocotylized third right arm of the male.

The Gloucester fishermen have brought in several specimens from the banks, off Nova Scotia and Newfoundland.

Professor G. O. Sars has taken it, off the Norwegian coast, in 60 to 300 fathoms.

Octopus piscatorum Verrill. (Fishermen's Octopus.)

This Journal, vol. xviii, p. 470, Dec., 1879.

Two specimens of this species, both females, have been obtained. The first was from LeHave Bank, off Nova Scotia, 120 fathoms, taken by Capt. John McInnis and crew, of the schooner "M. H. Perkins," Oct., 1879; the second was taken by Capt. David Campbell and crew, of the schooner "Admiral," near the Grand Bank, in 200 fathoms, Dec., 1879.

This species resembles *O. Grönlandicus*, of which the males alone have been described, and may prove identical.

Octopus obesus Verrill. (Stout Octopus.)

This Journal, vol. xix, p. 137, Feb., 1880.

One male, taken in 160 to 300 fathoms, east of Sable Island, N. S., by Chas. Ruckly, of the schooner "H. A. Duncan."

Octopus lentus Verrill. (Soft Octopus.)

This Journal, vol. xix, p. 138, Feb., 1880.

One specimen only, a female, presented by Capt. Samuel Peeples and crew, of the schooner "H. M. Perkins." It was taken near LeHave Bank, N. S., in 120 fathoms.

Stauroteuthis syrtensis Verrill. (Webbed devil-fish.)

This Journal, vol. xviii, p. 468, Dec., 1879.

PLATE XVI, figs. 1 to 5.

The only known specimen of this curious species was taken in N. lat. 43° 54′; W. long. 58° 44′, about 30 miles E. of Sable Island, N. S., in 250 fathoms, by Capt. Melvin Gilpatrick and crew, of the schooner "Polar Wave," Sept., 1879.

EXPLANATION OF THE PLATES.

PLATE XII.

Architeuthis princeps V. (No. 14). General figure; from the recently preserved specimen; restored, in part, in accordance with the measurements of the freshly caught specimen; $\frac{1}{15}$ natural size. Drawn by the author.

PLATE XIII.

Figure 1.—*Architeuthis Harveyi* (No. 5). Head and arms, $\frac{1}{3}$ natural size, from a photograph of the specimen when freshly caught. The back of the head rests upon an oar so as to cause the beak to protrude, while the arms hang down in a reversed position. The diameter of the bathing tub was 38·5 inches: *a*, left, and *a′*, right ventral arms; *b*, left, and *b′*, right arms of the third pair; *c*, left, and *c′*, right arms of the second pair; *d′*, right dorsal arm, mostly concealed behind the others; *e*, left and *e′*, right tentacular-arms, folded several times over the oar; *i* to *iv*, the 'club'; *i* to *ii*, the 'wrist'; *ii* to *iii*, the part bearing large suckers; *iii* to *iv*, the terminal division; *o*, the beak.

Figure 2.—Part of the body and caudal fin of the same specimen, $\frac{1}{3}$ natural size, from a photograph made at the same time with the preceding; *u*, mantle cut open; *t*, tip of tail; *b*, right and *l*, left lateral lobes of caudal fin.

PLATE XIV.

Histioteuthis Collinsii Verrill. Side-view of the head and arms; from the preserved specimen, $\frac{1}{4}$ natural size. Drawn by J. H. Emerton.

PLATE XV.

Figure 1.—*Rossia Hyatti.* Dorsal view, enlarged 1½.
Figure 2.—The same. A young specimen, enlarged 1½.
Figure 3.—*Rossia sublevis.* Ventral view, enlarged 1½.
Figure 4.—*Sepiola leucoptera.* Young, ventral view, enlarged 3 diameters.
Figure 5.—The same. A larger specimen, taken in 1879, enlarged 1½.

PLATE XVI.

Figure 1.—*Stauroteuthis syrtensis.* Dorsal view, $\frac{3}{10}$ natural size.
Figure 2.—The same. Lower side of head; *s*, siphon; *e*, eye; *a*, the pore.
Figure 3.—The same. The siphon, turned back.
Figures 4 and 5.—The upper and under jaws of the same, enlarged 2⅔ diameters.

ART. XXXV.—*Notices of Recent American Earthquakes.* No. 9; by Professor C. G. ROCKWOOD, Jr., Princeton, N. J.

IN these notices, as heretofore, those based upon *single* newspaper items, and which could not be otherwise verified, are printed in smaller type, and the source of the information is indicated.

I must again express my indebtedness for information received, to J. M. Batchelder, Esq., of Boston, to the U. S. Monthly Weather Review, and also to President J. W. Dawson of Montreal, Professor F. E. Nipher of St. Louis, and Professor R. A. Rice, of Burlington, Vt.

1878, June 9. A shock at Granada, Nicaragua, at 4.30 P. M., direction N.W. to S.E., duration seventeen seconds. This is evidently the same shock already reported at San José, Costa Rica. —III, xvii, p. 160.

June 16. Two severe shocks at Cerro de Pasco, Peru.

June 17. A slight shock at Granada, Nicaragua, at 11.15 A.M., direction N.W. to S.E., duration eleven seconds.

June 19. A severe shock at Cerro de Pasco, Peru at 1.30 A. M.

Oct. 31. At San José, Costa Rica, a very feeble shock at 9.30 A. M.

Nov. 3. At the same place, a feeble shock at 5.30 P. M.

Nov. 8. At the same place, a feeble shock at 8.15 P. M.

Nov. 23. At the same place, a quite strong shock.

Nov. 12. At Unalaska Island, Alaska, a slight shock at 2.30 A. M.—*U. S. Weather Review.*

Nov. 18. For additional notices of the earthquake on this day in Missouri, (already reported, III, xvii, p. 162), see vol. xvii, p. 260.

Nov. 26. A brief shock at Alajuela, Costa Rica, at 1.40 A. M.

Dec. 9. A severe shock at Red Bluff, Cal., at 3.20 P. M., lasting fifteen or twenty seconds.

Dec. 17. A slight shock at Yuma, Arizona, at 4 P. M., lasting eight seconds; felt also at Campo, Cal., where two shocks were reported, lasting about two seconds, direction from S. W., with rumbling noise.

Dec. 24. A slight shock at 9 P. M. at Flushing, N. Y., from N. to S., with rumbling noise.—*U. S. Weather Review.*

Dec. 28. A slight shock at Schoharie, N. Y., at 9.32 P. M.; felt also in other towns north of there, to a distance of 15 miles.

1879, Jan. 9. A severe shock at Arequipa, Peru, at 11.50 P. M.

Jan. 12. At Iquique, Peru, a long and violent shock about midnight, with subterranean noise.

Jan. 12. Apparently simultaneous with the above, a severe shock was felt in northern and central Florida. It occurred about 11.45 P. M. and affected the country bounded on the north by a line joining Tallahasse and Savannah, Ga., and on the south by a nearly parallel line from Punta Rassa on Tampa Bay through Okahumpka in the interior, to Daytona on the Atlantic coast. At most places two shocks were noticed, lasting altogether about thirty seconds. The statements of directions are very discordant, with however an apparent preference for N.W. and S.E. This direction agrees pretty well with the statements of time, which vary from 11.40 and 11.45 at Lake City and Jacksonville, to 11.50 at Savannah and Daytona, 11.55 at St. Augustine and Gulf Hammock, and 12 P. M. at Okahumpka, thus roughly indicating a progress from N.W. to S.E. The reports are not sufficiently exact to form a basis for any estimate of velocity.

Jan. 30. A strong shock between 10 and 11 A. M. at Colima, Mexico.—*U. S. Weather Review.*

Feb. 4. A shock at Visalia, Cal., at $0^h{\cdot}8^m$ A. M., lasting five seconds, with rumbling noise, and seven seconds later a second heavier shock lasting nine seconds. The motion "appeared to come from the S.E. or E.," and was felt in the surrounding country.

Feb. 12, 18, 26. At San José, Costa Rica, feeble shocks on 12th at 10.46 P. M.; on 18th at 3.10 A. M.; on 26th at 6.00, 6.10, and 6.30 A. M., with a stronger one at 4.40 P. M.

Feb. 19. A shock at San Francisco, Cal., a few minutes after 5 A. M.—*N. Y. Times.*

March 18. A strong shock at Alajuela, Costa Rica, at 0.15 A. M. and at San José at 0.17 A. M., oscillations E. to W., lasting ten seconds.

March 25. A shock was felt about 7.30 P. M. along the Delaware River below Philadelphia. It extended from Chester, Pa., to beyond Salem, N. J., a distance of about 30 miles, being felt most strongly on the east side of the river, where it was accompanied by a noise resembling thunder.

April 3, 4. At San José, Costa Rica, at 11.25 A. M. on the 3d, a feeble shock; and at 11.44 A. M. of the 4th, two strong shocks with an interval of five to seven seconds. At 2 P. M. of the same day a shock was felt at Puntarenas.

April 9. At San José, Costa Rica, two shocks at 11.15 and 11.34 A. M., the first and stronger one lasting about twenty seconds. The same shocks were reported from Alajuela at 11.07 and 11.25 A. M.

April 14. A shock at Norfolk, N. Y., at 11.15 A. M., from W. to E., lasting about forty seconds.

May 16 or 17. An earthquake in the morning at Vera Cruz, Mexico, and inland to Cordova and Orizaba. I have this from two sources differing in the day, although evidently referring to the same shock.

May 25. At 5.30 P. M., a rather heavy shock at St. Georges, Bermuda; felt also about the same hour in the islands of Porto Rico, St. Croix and Tortola, the nearest part of the Antilles.

May 26. Slight shock at Princeton, Cal., at 8.40 P. M.—*U. S. Weather Review.*

May 29, 30. On the night between these days, at 6.30 P. M. and 1.30 A. M., severe shocks occurred in Costa Rica, destroying some houses at San José, Alajuela and Grecia, and felt more lightly at Aspinwall, Panama and other places.

June 3. At 9.32 A. M. on Atka Island, Alaska, eight sharp shocks in rapid succession, lasting about two seconds each, direction S.SE. to N.NW.

June 11, 12. A light shock at 10 P. M. felt at Montreal and east and southeast from there as far as Waterloo and Frelighsburg. At Montreal it is described as "loud rumbling, slight shock and

continuation of rumbling." The direction was said to be N. to S. Some persons reported a second light shock and rumbling at 2 A. M. on the 12th.

June —. The Sacramento (Cal.) Union of June 28, speaks of a "recent earthquake at Virginia City," (Nev.) which was felt at the surface but *not* in the deeper mines. No more exact account has been obtained."

July 11. Two severe shocks at Bogota, Colombia, the first about 9 P. M., lasting ten seconds, the second about 11 P. M., lasting thirty seconds. They were accompanied by a slight rumbling noise; direction S.W. to N.E. The damage to property was slight.

July 26. A shock at Cairo and Mound City, Ill. at 11.45 A. M., lasting three seconds. Motion N. to S.

July 30. A violent shock at St. Thomas, (West Indies) at 11.35 A. M., lasting forty seconds.—*Nature.*

Aug. 1. A sharp shock at St. Thomas, (West Indies).—*J. M. B.*

Aug. 10. A severe shock was felt at Dominica, (West Indies), "at 1.20 A. M., and at intervals until 1.52 there were tremulous movements of the earth." A noise accompanied the first shock, after which "there was an interval of perfect quiet until 1.30 when subterranean noises like the booming of distant guns attracted attention; and then at intervals varying from two to five minutes, six of these discharges were counted, and following each there came a gentle tremulous movement." Dominica is stated to be "essentially of volcanic origin and contains three active geysers." —From a letter in *Nature*, xx, p. 431.

Aug. 10. At 1.15 P. M. a very light shock at Los Angeles Cal.; stronger and followed by a tidal wave at St. Monica 13 miles west; and quite severe at San Fernando about the same distance north.

Aug. 18. A shock at Fiske's Mills, Sonoma county, California.—*J. M. B.*

Aug. 21. The country between Lakes Erie and Ontario was severely shaken about 3 A. M. The earthquake was reported from Buffalo, Lockport and Niagara, on the New York side, and from various places as far west as Beamsville and Welland on the Canada side. At most places an explosion was heard and at St. Catharines the shock was strong enough to cause the church bell to make two taps. The time stated at Buffalo and Lockport is "1.30 to-day." If not an error, this would indicate another shock. Inquiry failed to remove the uncertainty. No report mentioned *two* shocks.

Sept. 24. A violent shock occurred in the southern part of Iceland, being most severe near Krísuvík. Slight local earthquakes had frequently occurred at Krísuvík during the previous eighteen months.

Sept. 25. A shock at 9.10 P. M. at Memphis, Tenn., lasting six seconds, direction N.W. to S.E. It was felt also at Gayoso, Mo.,

where "the sound appeared to be in the S.W. and the vibration to travel to the N."

Oct. 2. A sharp shock at 6.30 A. M., felt at Oakland and other places around San Francisco Bay.

Oct. 2. A strong shock in the morning at Arequipa, Peru, lasting thirty seconds. —*U. S. Weather Review.*

Oct. 24. At New Haven, Conn., at 6.12 P. M. two slight shocks, felt also at Bridgeport.

Oct. 25. Two shocks at 10.30 P. M. at Peterboro, N. H.—*J. M. B.*

Oct. 26. A slight shock at Winsborough, S. C.—*U. S. Weather Review.*

Nov. 3. A slight shock at Contoocook, N. H., at 7.15 A. M.

Nov. 13, 14, 15, 16. Numerous shocks in Valparaiso, Chili.—*London Times.*

Nov. 18. A slight shock at 10.40 A. M. in Costa Rica.—*U. S. Weather Review.*

Nov. 25. A slight shock at Boise City, Idaho, lasting about two seconds, vibration E. to W.; felt also at Idaho City, 35 miles north, where another faint shock was noticed on the 26th.

Dec. 7. A slight shock at Los Angeles, Cal., at 8.15 P. M., lasting about two seconds.—*U. S. Weather Review.*

Dec. 12, 13. Two distinct shocks from W. to E. at 7 P. M. of the 12th, and 2 A. M. of the 13th, were felt at Charlotte, S. C., and in the surrounding country within a radius of eleven miles.

Dec. 21. In the district of San Salvador, C. A., was felt the first of a series of earthquakes which continued with greater or less violence up to and after Jan. 1, 1880. Shocks of especial severity occurred on Dec. 27, and at La Libertad at 7.30 P. M. on Jan. 1. Fears were entertained for the safety of the capital and other towns in the interior. Fuller details are hoped for in due time.

Dec. 29. A shock at Yankton and Fort Sully, Dakota, at 12.30 A. M. with rumbling noise.

1880, Jan. 9. A shock about the Bay of Monterey, Cal., felt at Santa Cruz, Gonzales and Hollister, about 5.45 A. M., lasting 15 to 20 seconds, direction N.E. to S.W.

Jan. 22, 23. Severe shocks were felt at Key West, in Havana and the western part of Cuba and in the Isle of Pines. The principal and most widely felt shocks occurred about 11 P. M. of the 22d and 4 A. M. of the 23d; with others more local in character about 9 P. M. of the 23d, 4 A. M. and 1 P. M. of the 26th, and on the morning of the 29th. No damage was done at Havana, but at Vuelta Abajo and San Christobal, twelve miles distant, many buildings were thrown down and some lives lost. The direction of motion was S.W. to N.E., and a subterranean roaring was heard.

Feb. 8. A slight shock near Ottawa, between 8 and 9 P. M.—*N. Y. Tribune.*

Feb. 23, 24. Light shocks at San Christobal, Cuba, at 6.30 P. M. and 3.20 A. M., the latter accompanied by an explosive noise.

Princeton, N. J., March 2, 1880.

ART. XXXVI.—*Observations on the Height of Land and Sea Breezes, taken at Coney Island;* by O. T. SHERMAN.

THE following observations were taken at Coney Island with the captive balloons of the American Aeronautic Society, S. A. King, aeronaut in charge. Captain Howgate furnished the observer.

With the exception of the hotels, no height rises to interrupt the flow of the wind. We might expect, therefore, to find the sea breeze and its counter current undisturbed. The standard thermometer employed was of the Signal Service pattern, made by James Green, and carefully tested by the observer. The aneroid barometers were kept compared with a standard mercurial instrument at the surface. The anemometer, of Robinson's pattern, furnished by James Green, was used to measure the velocity of the wind at the top of the ascent, and also at the bottom. In the other cases, the forces were estimated.

The record was commenced as the balloon left the earth and continued without interruption till the balloon attained its highest point. At the top, the velocity of the wind was recorded by a "five minute" observation. On the descent the same plan was followed.

From the barometric readings, reduced to the mercurial standard, the heights were deduced by Loomis' table as given by Guyot. A comparison of these heights with those deduced from the length of the rope in use showed a close agreement. The thermometric readings reduced to the standard thermometer were then plotted in a curve whose ordinates were heights, and the abscissas, the degrees of the thermometric scale. The ascent and descent giving somewhat discordant values, a free hand curve was drawn between them. The positions of the curve are given in the annexed table. The force of the wind was treated in a like manner. The observed directions were then plotted opposite the heights. When discordant at one height, they were referred to that one of the sixteen equal divisions of the compass which lay between them. The whole was then referred to the mean of the times of leaving and regaining the earth, an interval of about fifteen minutes. New York time was employed. The results are given on the following page.

A slight inspection of the return rates of change shows that the return current has influenced the temperature of the air around it to a noticeable extent.

We may consider the observed wind as composed of the wind produced by a great storm in progress, and the sea or

Table showing the direction and force of wind at the different heights

Table showing the direction and force of wind and the temperature at heights from 0 *to* 1200 *feet above the beach at Coney Island, New York.*

The first line in the table gives the heights above the ground in feet. The upper numbers indicate the temperature in Fahrenheit degrees. The lower the direction and velocity of the wind. —— indicates no record of direction, or rather a direction between the two neighboring directions.

Day.	Hour.	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
1879.	h m	78·5	76	74·8	74·0	73·5	73·3	73·3						
July 31	10 15	NE. 3	—— 2·3	N. 2	—— 2·1	NW. 2·3	—— 2·4	NW. 3						
		79·0	77·2	77·0	77·2	77·7	78·2							
" 31	2 46	SW. 2·8	S. 2·6	S. 2·0	S. 1·8	—— 1·3	Calm.			NW.*				
		74·0	73·4	73·5	74·0	74·2	75·0							
" 31	7 26	SSW. 2·8	—— 2·8	S. 3·0	—— 3·0	—— 2·8	SSE. 2·2							
		77·0	76·6	75·2	74·3	74·2	74·2							
Aug. 1	9 46	SSW. 3	—— 3	SW. 4	SW. 5·6	SW. 7	SW. 7·5							
		82·0	77·2	76·0	75·2	74·8	74·4							
" 1	10 54	SSW. 5	—— 5	SSW. 5·5	—— 6·0	—— 6·5	SSW. 6·5							
		76·8	75·0	75·2	75·8	76·0								
" 2	9 0	SW. 3	—— 6·3	WSW. 7·0	W. 6·8	W 6·3								
		84·0	84·2	84·6	85·2	85·6	86·0	86·2	87·0					
" 2	1 55	SSE. 9·0	SSE. 7	S. 5·0	S. 4·5	——	SSW. 5·0	—— 4·5	SW. 4·5					
		70·5	68 2	67·6	67·3	67·0	67·0	66·4	66·2	66·0	65·6	65·3	65·0	64·7
" 10	1 19	NNE. 2·0	—— 5·0	—— 5·4	—— 5·4	N. 6·0	—— 7·5	—— 8·7	—— 8·0	—— 6·0	—— 4·5	—— 5·0	NW. 5·2	NW. 5·7
		73·3	72·7	72·2	71·8	70·8	69·5	68·8	68·0	68·0	68·0	67·6	67·2	66·8
" 10	3 10	NW. ·3	—— 5·3	—— 7·5	—— 9·0	—— 11·0	—— 13·5	—— 16·5	—— 16·5	—— 14·0	—— 12·0	—— 11·5	—— 11·7	NW. 12·0
		72·8	71·0	70·3	69·8	69·2	68·5	68·0	67·5	67·0	66·8	66·4	66·2	66·0
" 10	5 42	NW. ·3	NW. 4	—— 4	—— 3	—— 3	—— 3·8	NW. 4	—— 4	NW. 4	—— 4·0	—— 4·0	—— 4·0	NW. 3·8
		79·0	74·8	73·9	73·0	72·4	71·7	71·2	70·6	70·6	70·5	70·4	70·0	
" 11	2 10	SSE. ·8	SSE. 8·3	—— 9·3	S. 8·2	S. 7·0	SSW. 6	—— 5·5	SSW. 5·2	—— 5·0	—— 5·2	—— 7·5	SSW. 10·5	
		74·5	73·2	72·7	72·7	72·7	72·7	72·0	72·0	72·0	72·0	71·5	71·3	71·1
" 12	10 50	S. 5	—— 5	—— 4·5	SW. 4·5	SW. 4·5	SW. 4·5	WSW. 3·6	WSW. 4·0	W. 4·5	—— 5·0	WNW. 6	—— 6	NW. 6·3
		78·0	71·5	71·3	70·6	70·0	69·6	69·5	69·2	69·2	69·2	68·7	68·2	68·3
" 13	11 50	SSE. 7·5	SSE. 8·4	SSE. 8·4	S. 8·4	SSW. 7·6	—— 5·0	SW. 3·8	WSW. 4·2	W. 4·7	WNW. 5·8	WNW. 6·8	WNW. 10·5	WNW. 12
		80·3	80·0	79·2	78·7	78·2	77·8	77·4	77·8					
" 14	1 42	SSE. 7·2	—— 4	—— 4·5	S. 7·5	SW. 9·8	SW. 11	—— 11·5	W. 12					

* Shown by a toy balloon as compared with the captive.

land breeze. The sea breeze blows perpendicular to the coast, or about southeast. To obtain the storm wind, I examined the 7·35 A. M. maps of the Signal Service, but since the observations were taken almost directly under areas of maximum pressure, the examination gave no useful results. I therefore adopted a method based upon the following considerations. Of all those directions and velocities which combined with the direction of the sea breeze can produce the resultant, the storm breeze is that which remains when the sea breeze vanishes; the fact that the sea breeze vanishes is shown by the other component remaining undisturbed. For example, on August 13, the observed wind was S.S.E., velocity 7·5 miles. This might be produced either by S. 4·5, S.E.; S.S.W. 4, S.E., S.W. 3, S.E., etc., but of these, S.W. 3 most nearly satisfies the condition that it shall be observed by itself. The surface breeze therefore ends at about 650 feet from the surface of the sea, while above 700 feet a current from the land evidently deflects the breeze toward the northwest. Proceeding with each of the other cases in the same way a mean may be taken. In this manner we have drawn up the following table. The values, though necessarily approximate, gain much from our inability to launch the balloon save on calm days. The sign $<$ implies that the given value is probably too high.

Day.	Hour.	Surface breeze ends.	Return breeze begins.	Return breeze ends.
1879.	h m			
July 31	10 15 A. M.	$<$175 feet.	$<$400 feet.	
	2 46 P. M.	$<$500 feet.	About 750	
	7 26 P. M.	$<$375 feet.	$<$400 feet.	
August 1	9 46 A. M.	200? feet.	$<$300? feet.	
	10 54 A. M.	Above	the highest	point reached.
2	9 0 A. M.	$<$200 feet.	$<$250 feet.	
	1 55 P. M.	$<$200 feet.	$<$600 feet.	
10	1 19 P. M.	$<$400 feet.	$<$500 feet.	$<$ 900 feet.
	3 10 P. M.	$<$500 feet.	500 feet.	$<$1100 feet.
	5 42 P. M.	None.	None.	
11	2 10 P. M.	$<$825 feet.	$<$900 feet.	
12	10 50 A. M.	$<$600 feet.	$<$800 feet.	
13	11 50 A. M.	$<$650 feet.	$<$700 feet.	1050 feet?
14	1 42 P. M.	$<$300 feet.	$<$400 feet.	

It becomes evident that both current and counter current are low in the atmosphere. They will perhaps serve to explain a fact often noticed, that though we could plainly see the steam from the locomotives as they whistled, yet could hear no sound though nearly above the track.

Art. XXXVII.—*On a New Method of Spectrum Observation;* by J. N. Lockyer.*

In anticipation of my report on the Methods of Mapping Spectra, which I have been requested to prepare for the Solar Committee, I beg to present to them the following account of some recent work which has been suggested during the preparation of that report.

In the Philosophical Transactions for 1873 (p. 254) I gave an historical account showing how, when a light source such as a spark or an electric arc is made to throw its image on the slit of a spectroscope, the lines had been seen of different lengths, and I also showed by means of photographs how very definite these phenomena were. It was afterwards demonstrated that chemical combination or mechanical mixture gradually reduced the spectrum by subtracting the shortest lines, and leaving only the long ones.

On the hypothesis that the elements were truly elementary, the explanation generally given and accepted was that the short lines were produced by a more complex vibration imparted to the "atom" in the region of greatest electrical excitement, and that these vibrations were obliterated or prevented from arising by cooling or admixture with dissimilar atoms.

Subsequent work, however, has shown† that of these short lines *some* are common to two or more spectra. These lines I have called basic. Among the short lines, then, we have some which are basic, and some which are not.

The different behavior of these basic lines seemed, therefore, to suggest that not all of the short lines of spectra were, in reality, true products of high temperature.

That some would be thus produced and would therefore be common to two or more spectra we could understand by appealing to Newton's rule: "Causas rerum naturalium non plures admitti debere quam quæ et veræ sint et earum phænomenis explicandis sufficiant," and imagining a higher dissociation. It became, however, necessary to see if the others would also be accounted for.

I have already given to the Royal Society a preliminary account of the extraordinary, because unexpected, phenomena and changes observed in the spectra of vapors of the elementary bodies when volatilized at different temperatures in vacuum tubes. Many of the lines thus seen alone and of surpassing brilliancy, are those seen as short and faint in ordinary

* Received for publication from the author.

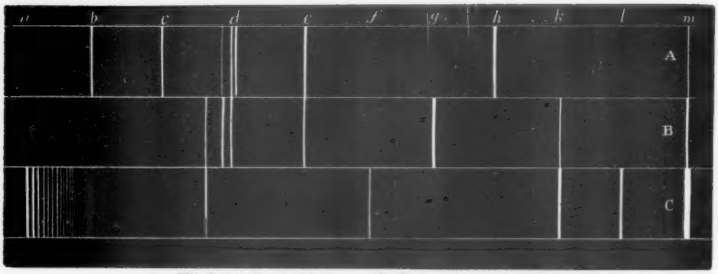
† Proc. Roy. Soc., vol. xxviii, p. 159.

methods of observation, and the circumstances under which they are seen suggest, if we again appeal to the above rule, that many of them are produced by complex molecules.

In this case the appeal lies to the phenomena produced when organic bodies are distilled at varying temperatures; the simplest bodies in homologous series are those volatilized at the lowest temperatures; so that on subjecting a mixture of two or more liquids to distillation, at the beginning a large proportion of the more volatile body comes over, and so on.

At any particular heat-level, then, some of the short lines may be due to the vibrations of molecular groupings produced with difficulty with the temperature employed, while others represent the fading out of the vibrations of other molecular groupings produced on the first application of the heat.

In the line of reasoning which I advanced a year ago,* both these results are anticipated, and are easily explained. Slightly varying fig. 2 of that paper, we may imagine furnace A to represent the temperature of the jar spark, B that of the Bunsen burner, and C a temperature lower than that of the Bunsen burner.



A. Highest temperature. C. Lowest temperature.

Then in the light of the paper the lines *b* and *c* would be truly produced by the action of the highest temperature, *c* would be short and might be basic, while of the lines *h* and *m*, *m* would be short and could not be basic, because it is a remnant of the spectrum of a lower temperature.

To make this reasoning valid we must show then that the spark, or better still the arc, provides us with a summation of the spectra of various molecular groupings into which *the solid metal which we use as poles* is successively broken up by the action of temperature.

We are not limited to solid metals; we may use their salts. In this case it is shown in the paper before referred to† that in very many cases the spectrum is one much less rich in lines.

I have therefore attempted to gain new evidence in the re-

* Proc. Roy. Soc., vol. xxviii, p. 162.

† Phil. Trans., 1873, p. 258.

quired direction by adopting a method of work with a spark and a Bunsen flame, which Col. Donnelly suggested I should use with a spark and an electric arc. This consists in volatilizing those substances which give us flame spectra in a Bunsen flame and passing a strong spark through the flame, first during the process of volatilization, and then after the temperature of the flame has produced all the simplification it is capable of producing.

The results have been very striking; the puzzles which a comparison of flame spectra and the Fraunhofer lines has set us find, I think, a solution; while the genesis of spectra is made much more clear.*

To take an instance, the flame spectrum of sodium gives us as its brightest, a yellow line, which is also of marked importance in the solar spectrum. The flame spectra of lithium and potassium give us, as their brightest, lines in the red which have not any representatives among the Fraunhofer lines, although other lines seen with higher temperature are present.

Whence arises this marked difference of behavior? From the similarity of the flame spectrum to that of the sun in one case, and from the dissimilarity in the other, we may imagine that in the former case—that of sodium—we are dealing with a body easily broken up, while lithium and potassium are more resistant; in other words, in the case of sodium, and dealing only with lines recognized generally as sodium lines, the flame has done the work of dissociation as completely as the sun itself. Now it is easy to test this point, for if this be so then (1) the chief lines and flutings of sodium should be seen in the flame itself and (2) the spark should pass through the vapor after complete volatilization has been effected without any visible effect.

Observation and experiment have largely confirmed these predictions. Using two prisms of 60° and a high-power eyepiece to enfeeble the continuous spectrum *of the densest vapor produced at a high temperature*, the green lines, the flutings recorded by Roscoe and Schuster, and another coarser system of flutings, so far as I know not yet described, are beautifully seen. I say largely, and not completely, because the double red line and the lines in the blue have not yet been seen in the flame, either with one, two or four prisms of 60°, though the lines are seen *during volatilization* if a spark be passed through the flame. Subsequent inquiry may perhaps show that this is due to the sharp boundary of the heated region, and to the fact that they represent the vibrations of molecular groupings more complex

* I allude more especially to the production of triplets, their change into quartets, and in all probability into flutings, and to the vanishing of flutings into lines, by increasing the rate of dissociation.

than those which give us the yellow and green lines. The visibility of the green lines, which are short, in the flame, taken in connection with the fact that they have been seen alone in a vacuum tube, is enough for my present purpose.

With regard to the second point, the passage from the heat-horizon of the flame to that of the spark, after volatilization is complete, produces no visible effect, indicating that in all probability the effects heretofore ascribed to *quantity* have been due to the presence of the molecular groupings of greater complexity. *The more there is to dissociate, the more time is required to run through the series, and the better the first stages are seen.*

Let us now turn to lithium.

Seeing that the red line is absent while the violet lithium line is strong among the Fraunhofer lines, we may imagine that the flame has not done the work of dissociation in the case of lithium as completely as the sun does it, so that (1) the other lines of lithium should not be visible, even with the new precautions, in the flame spectrum, and (2) a passage from the heat-level of the flame to that of the spark after volatilization should produce the other lines which we know to exist in the spectrum of the metal in the orange, blue and violet.

Experiment and observation have also confirmed this result, so far as the yellow and blue lines go; that in the violet is difficult of observation.*

We next come to potassium.

The potassium lines usually recorded as not seen in a flame, but which are observed with a spark, are not very brilliant; nor are they strong among the Fraunhofer lines. Seeing, therefore, that a high temperature does not greatly develop them, we may expect to find them in the flame. They are almost all there when they are looked for with proper precautions, but those in all probability present in the sun are brightened on passing the spark, showing apparently that the flame volatilizes with some difficulty the molecule which gives the line in the red.

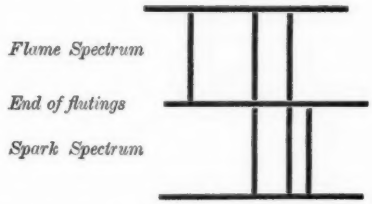
The flame spectrum of magnesium perhaps presents us best

* The way in which the lines in the flame are unaffected by the spark strikingly reminds me of the following remarks of Angström and Thalén: "The Fraunhofer lines can in general be divided, according to their appearance, into two classes; the one sharply defined and tolerably deep black, the other by no means so decidedly marked either as to form or color. These two different kinds of lines are, as regards their appearance, very happily characterized by the opinion expressed on a former occasion, that the former, especially when the illumination is feeble, look as if they were situated considerably in front of the faint ground on which the latter seem to lie. The most prominent lines of the former class almost all proceed from iron; and those which remain, after the iron-lines are abstracted, belong to the other metals; calcium, manganese, chromium, etc."—("Angström and Thalén on the Fraunhofer Lines, together with a Diagram of the Violet Part of the Solar Spectrum." Upsala, 1866, p. 5.)

with the beautiful effects produced by the passage from the lower to the higher heat-level, and shows the important bearing on solar physics of the results obtained by this new method of work.

In the flame the two least refrangible of the components of *b* are seen associated with a line less refrangible, so as to form a triplet. A series of flutings and a line in the blue are also seen.

On passing the spark, all these but the two components of *b* are abolished. We get the wide triplet replaced by a narrow one of the same form, the two lines of *b* being common to both, thus—



When the line in the blue disappears on passing the spark, two new lines are seen. The spark lines are in the sun, but the less refrangible member of the wide triplet and the blue line seen in the flame are absent.

The following are the details of some of the experiments which have been made on the above points:—

Experiment No. I.—Two pieces of platinum wire were supported in a Bunsen flame at a distance from one another of about three millimeters. They were then connected with a Holtz machine, in order that the spark might be passed inside the flame.

An image of the platinums was then thrown on the slit of the spectroscope by means of a lens. The spectroscope used had two dense flint prisms of 60°.

A piece of charcoal soaked in solution of sodium chloride was put into the base of the flame first, and then just below the platinum, and the spectrum observed; it consisted simply of the yellow line D. The spark was passed and the spectrum again observed; it now consisted of D plus the lines of hydrogen and some air lines, the red and green Na lines and the green flutings being still absent.

Experiment No. II.—Same arrangements, except that a large induction coil was substituted for the Holtz machine. The same results were obtained with the sodic chloride.

Experiment No. III.—Metallic sodium was next tried. It was found that when the metal was put into the flame just

below the platinums the green line and the flutings were seen without the spark, that is, at the ordinary temperature of the flame. On introducing the sodium into the lower part of the flame, the green double (λ 5687·2 and 5681·4) and the flutings were not seen, either with or without the spark.

Experiment No. IV.—Same arrangements as No. II, with metallic sodium, and with a small blowpipe instead of Bunsen.

In this experiment the flame spectrum showed, besides the yellow line (D), the green double (λ 5687·2 and 5681·4), and also the flutings in the green, those in the red being absent. As soon as the spark was passed, the green double (λ 5687·2 and 5681·4) became brighter, while the flutings vanished.

In these observations the sodium was put into the flame *just below the platinums.* When put into the bottom of the flame, the D line was seen alone.

Experiment No. V.—A glass tube $\frac{1}{2}$ inch in diameter was prepared, about six inches in length, having two platinums sealed into it at a distance of four inches from each other. A bulb was blown at each end, so that the spectrum might be examined with the tube end-on. A piece of sodium was put into the tube, and the latter exhausted with a Sprengel pump. An Argand burner was placed at one end of the tube, in order that the absorption of the vapor, as well as its radiation, might be observed. The metal was then very gradually heated by a Bunsen flame.

After the heating had gone on for about twenty minutes the absorption line of D appeared; this gradually increased in intensity.

On passing the spark along the tube, the bright lines of sodium appeared, the green double (λ 5687·2 and 5681·4), being distinguishable after D had been seen for a little time alone.

The temperature was now increased and the absorption spectrum again examined. The flutings in the green gradually made their appearance, D increasing in intensity, the green line being invisible. Afterwards the flutings in the red came in.

On passing the spark the absorption spectrum, consisting of the red and green flutings disappeared instantaneously, and the green double was seen very bright; after the passage of the spark D dark was much increased in breadth.

The quantity of hydrogen given off during the change prevented the passage of the spark, and the observations had to be discontinued. As soon as some of this had been pumped out the same observations were repeated with the same results.

Experiment No. VI.—An experiment was made with lithium chloride in Bunsen flame, with the same arrangement as in Experiment No. 1.

The flame spectrum with the dispersion employed showed no Li line except the red one (λ 6705·2). On passing the spark from the Holtz machine, the yellow line (λ 6102·0) and the blue line (λ 4602·7) appeared as bright as the red line. The same results were obtained on repeating the experiment with the large induction-coil.

Experiment No. VII.—Potassium nitrate was tried by the method previously described in Experiment No. 1.

The flame spectrum consisted as usual of the red lines (λ 7697 and 7663) and the blue line (λ 4045), very faint.

The effect of the spark was to bring out the yellow lines (λ about 5800), those in the green (λ about 5340), and the red double (λ 6946 and 6913) out of the flutings visible in the red, the double at 7697 and 7663 not being affected. The experiment was repeated with the induction-coil, and the same observations made, with the additional one that the spark also slightly intensified the blue line.

Experiment No. VIII.—On repeating the experiment with metallic potassium, the same phenomena were more markedly observed, the lines about λ 5800, and other lines more refrangible, were visible as very faint objects in the flame; they were much strengthened, however, by the passage of the spark.

Experiment No. IX.—Some potassium was volatilized by the spark in front of the slit of the sun-spectroscope and comparison of the positions of the lines with the Fraunhofer lines made. It is believed that λ 5829·0, 5802·0, 5782·5 are all reversed in the solar spectrum. The less refrangible member of the red double (λ 6946) was next compared, and was undoubtedly absent from the sun. These observations, however, are rendered extremely difficult on account of the fluted appearance of the yellow lines, and must be repeated with a stronger sun and the electric arc. The spectroscope employed had three prisms, one of 60° and two of 45°.

Experiment No. X.—The flame spectrum of magnesium was examined, a green triplet was observed which was at first sight taken for *b*. Measurements of the lines, however, showed that the less refrangible member was less refrangible than *b*, and had a wave-length 5209·8, and that the other two members were b^1 and b^2 respectively. A fresh charge of magnesium was put into the flame and the spark passed; the original triplet was now no longer visible, the line at 5209·8 having vanished, but b^4 was now seen forming with b^1 and b^2 a triplet of similar form on a smaller scale.

According to Thalén, there are three blue lines of magnesium at w.l. 4481·0, 4586·5, and 4703·5. These lines were looked for in the flame with and without the spark. Without the spark only one line was visible in this region; its position

was found by comparison with the solar spectrum, to be at w.l. 4570·3, and coincident with no Fraunhofer line. The passage of the spark abolished this line, at the same time bringing in the two lines given by Thalén at w.l. 4481·0 and 4703·5, both of which are reversed in the solar spectrum.

No line was seen at Thalén's w.l. 4586·5, the nearest approach to which was the line seen at the temperature of the Bunsen flame at w.l. 4570·3, a difference of more than sixteen divisions of the scale.

I am now preparing maps showing the phenomena observed at various heat-levels. I think it is not too much to hope that a careful study of such maps, showing the results already obtained or to be obtained, at varying temperatures, controlled by observation of the condition under which changes are brought about, will, if we accept the idea that various *dissociations* of the molecules present in the solid are brought about by different stages of heat, and then reverse the process, enable us to determine the mode of evolution by which the molecules vibrating in the atmospheres of the hottest stars *associate* into those of which the solid metal is composed. I put this suggestion forward with the greater confidence, because I see that help can be got from various converging lines of work. To some of these I may briefly allude here:—

1. We have the lines present in the solar spectrum and absent from it.

Example.—The red potassium line present in the flame is absent from the sun; some of the other lines are present.

2. We have the varying thicknesses of the lines of any one element in the sun to compare with the thicknesses produced at different temperatures in the laboratory.

Example.—The various lines of magnesium, notably *b*, the most refrangible line given by Thalén and the other blue line.

3. We have the remarkable behavior of metals vaporized in a vacuum at the lowest temperatures.

Example.—Sodium gives us D, potassium gives us the triplet in the green-yellow; calcium gives us the line in the blue; thus separating those lines from all the others of those metals.

4. We have the remarkable behavior of the same vapors under like circumstances, the temperature alone being changed; when this is increased lines visible under ordinary conditions are brought in, and are seen in different parts of the tube, so that each line in turn (and therefore, I presume, each molecule which produces it) is separated from those with which it is generally seen in company.

Example.—By increasing the temperature we get the green line of sodium without D, and some of the magnesium lines have been seen separated from the others.

5. We have the power of determining the lower states by means of absorption phenomena and then of observing the radiation of the vapors produced by the passage of a feeble current of electricity.

Example.—The fluted spectrum of sodium described by Roscoe and Schuster is instantly abolished by this means and a brightening of the green and a considerable thickening of the dark yellow lines is seen.

6. May we consider the existence of these molecular states as forming a true basis for Dalton's law of multiple proportions? if so, then the metals in different chemical combinations will exist in different molecular groupings, and we shall be able by spectrum observations to determine the particular heat-level to which the molecular complexity of the solid metal induced by chemical affinity corresponds.

Examples.—None of the lines of magnesium special to the flame spectrum are visible in the spectrum of the chloride either when a flame or a spark is employed. The facts recorded in my papers, printed in the Philosophical Transactions some years ago, on the spectra of salts and mixtures, seem all explained in this way.

I think then that the method of mapping, to be complete, should not only show the metallic lines as produced at various temperatures compared with the Fraunhofer ones, but that for each metal investigations should be made and recorded for as many heat-levels as possible, and for various chemical groupings such as

Cr O	Fe_2Cl_6
Cr O_2	Fe Cl_2
Cr_2O_3	Fe
Cr,	

to give examples, with a view of investigating the facts, to see whether we can trace a molecular evolution in each case.

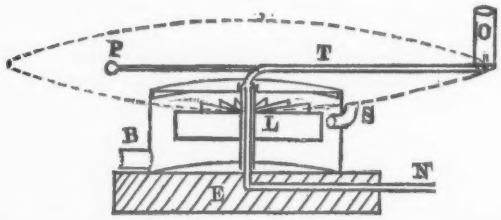
Further, the "basic lines recorded by Thalén will require special study with a view to determine whether their existence in different spectra can be explained or not on the supposition that they represent the vibrations of forms, which, at an early stage of the planet's history, entered into combination with other forms, differing in proximate origin, to produce different "elements."

ART. XXXVIII.—*The Presentation of Sonorous Vibrations by means of a Revolving Lantern;* by HENRY CARMICHAEL, Ph.D. (Göttingen).

AT the meeting of the American Association for the Advancement of Science at Hartford in 1874, a paper was read by the author on "A new method for the presentation of sound waves," in which was described the arrangement represented in fig. 1.

The principal novelty of this consists in a small lantern containing a coal-gas flame connected with a König's manometric capsule, the upright lantern being so placed at the end of a horizontal arm that it could be rapidly revolved in the horizontal plane.

1.



The frequent destruction of the glass cylinder forming the lantern led to the advantageous substitution of a mica cylinder. The cylinder O is open at both ends, and on being slightly inclined backward from the vertical of the plane of revolution it effectually screens the flame which would be otherwise immediately extinguished.

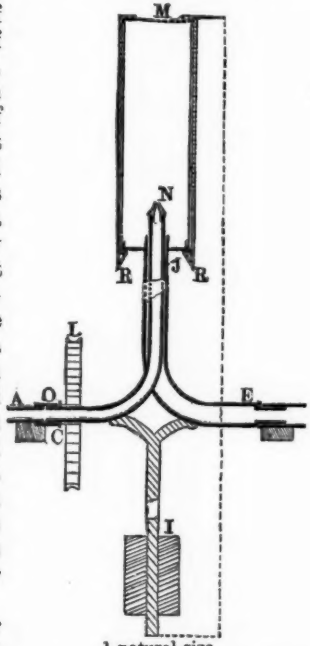
The lantern arm T is bent in to the vertical axis of revolution, and by an enlargement at this place it is made to slip over and form a gas-tight joint with the right-angled tube N, which is firmly fastened in the base block E. The rotation of the lantern is conveniently maintained by a small water-wheel L attached to the vertical shaft. The water enters the case at S and escapes at B. That the lantern may run smoothly the moment of the lantern O is counteracted by the adjustable weight P.

Flexible tubing connects N with König's manometric capsule. When no sound enters the capsule a smooth band of light appears, which, on the introduction of sound, is broken into a series of teeth, large or small, simple or compound, according to the nature of the sound. The peculiarities of this flame-band can be seen from the most distant parts of an audience room.

Although the performance of this instrument was highly satisfactory, it was exceeded in the following modification, (fig. 2), which, though hitherto unpublished, has been publicly used by me during the last three years.

The advantages of a sensitive flame, which is made to revolve in the vertical plane, must be obvious. Not only are all the teeth representing the sound waves brought within the field of vision, and the foreshortening of the teeth upon either side avoided, but by the introduction of oxygen into the lantern the brilliancy of the flame is greatly increased. It is important that the lantern and other moving parts be made as light as possible. The thin mica cover of the lantern is conveniently brought into shape by placing it upon a sheet of thin metal somewhat larger than itself, the whole central portion of which within a centimeter of the edge has been removed. The thin metal is folded over the edges of the mica which are to be brought into contact, and they are then held in place by a narrow strip bent traversely upon itself until it has the section of the letter C (fig. 3). The mica is thus readily bent without cleaving or rumpling.

2.



½ natural size.

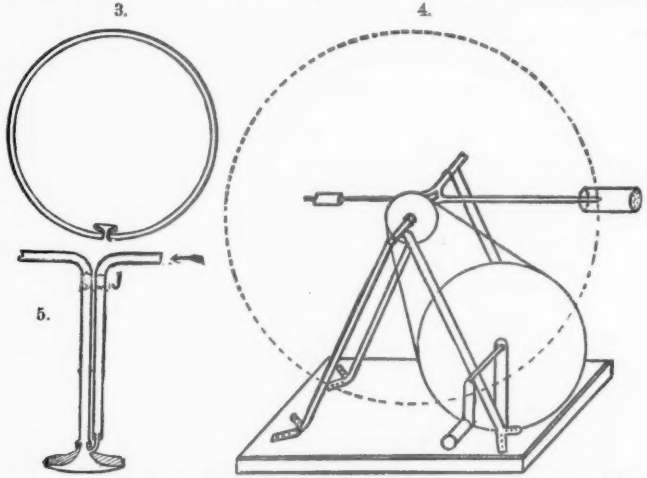
The distal end of the cylinder is covered with a perforated disc like the top of a pepper-box, and to the disc are fastened two wire springs, RR, by which the cylinder is quickly and firmly secured to the flange at the opposite end. The well-made steatite tip N should have such an internal diameter that the coal gas under full head will send the flame to the top of the lantern.

The central gas supply-tube is bent at right angles into the axis of revolution, and by means of a leather washer is made gas tight in the socket O. Commencing just below the gas-tip, the oxygen supply-tube is made concentric with the former, until, being bent at a right angle, it leaves it to form with it the shaft of the instrument. The joints at C and E are made gas-tight with little friction by the slight inward spring of the iron supports.

The lantern is revolved by a multiplying wheel, or by a powerful clock-work, when a uniform motion is required. Fig. 4 shows the general arrangements of parts.

When the oxygen is diluted with two measures of air it is more easily regulated as a supporter of combustion. The brilliancy of the flame is considerably increased by conducting the coal gas through a sponge saturated with "gasoline."

By regulating the flow of gases and giving the flame a rapid rotation, a continuous brilliant ring is produced, which is broken up into saw-like teeth, characteristic of the pitch, in-



tensity and quality of the entering sounds. A shrill whistle produces teeth so fine that they are barely visible at a distance of thirty feet. A loud low sound of the human voice affords teeth of the height of the lantern, three or more inches long, with one or two harmonic teeth surmounting the fundamentals. A rough roar yields large jagged teeth, exceedingly complicated and curious.

On turning down the flame the teeth are reduced to brilliant dots, with smaller dots between them if the harmonics be present. It is curious to observe that no trace of flame can be seen between these dots, which may be three inches or more apart. It is not to be presumed, however, that the flame is extinguished, as it is possible to arrange the flow of gases so that the flame is invisible during a complete rotation, and yet be restored by simply altering the proportion of the inflammable gases.

For investigating the motions of sonorous bodies an attachment is substituted for the manometric capsule, which may

be called the manometric pad, which is represented in figure 5. This consists simply in a wooden funnel, the mouth of which is covered with thin rubber, and the neck connected with two flexible tubes, one of which brings the supply of coal gas, and the other conveys the sonorous vibrations to the revolving lantern. On placing the manometric pad distended with gas in direct contact with vibrating strings, bells, tuning-forks, etc., their movements are readily studied in the flame band. By sliding the pad over the sonorous body the node and vibration segments are readily located. The interference and extinction of sounds may easily be presented by this apparatus.

The revolving flame was designed primarily for the elucidation of the principles of sound, and this it renders simple by the clearness and brilliancy of its phenomena, as well as the direct view of the vibrating flame, which it gives instead of the image usually seen.

For purposes of research the lantern is given a uniform rate, and the length of the flame band made a simple multiple of the wave length. There appears to be no limit to the velocity of rotation, although when the radius is made shorter or the velocity made greater than has been found as yet necessary, it will probably be preferable to introduce the jet at the outer end of the lantern, as only thus can the heated gases of combustion flow, as the force of rotation would impel them. A lantern upon the end of a long wand, to which a thin flexible tube leads, is easily constructed by any one, and when waved back and forth gives only less effectually the phenomena of the revolving lantern. Owing to the brilliancy of the flame, there is presumably no difficulty in the way of the direct photography of it.

Art. XXXIX.—*On the Chemical Composition of Childrenite;* by S. L. Penfield.

After the publication by Messrs. Brush and Dana* of their paper in which the new species, eosphorite, was described and shown to be closely related both physically and chemically to childrenite, they proposed to me to make a new investigation of the composition of the latter species with a view to deciding the uncertainty in regard to its true formula. Professor Brush very kindly placed at my disposal a suitable specimen from Tavistock out of his collection. From this the material for the following analysis was taken. The crystals were small, of a yellow-brown color, and were very carefully picked

* This Journal, July, 1878.

from the siderite and oxide of iron with which they were associated. Only lustrous crystals were accepted, and any doubtful material was discarded. Between eight and nine tenths of a gram were thus obtained. Analysis I is a complete analysis made on a little over half a gram; it was conducted with the greatest care and a special test was made for alkalies, so that they might be determined quantitatively if present. As Church in his analysis found iron sesquioxide present, the remaining three tenths of a gram of the mineral were tested quantitatively with potassium permanganate; the result indicated 26·08 per cent of FeO, varying only 0·12 per cent from gravimetric determination of iron protoxide in the same portions; so that we may conclude that the mineral really contained no iron sesquioxide. After titrating with potassium permanganate the solution was reserved, and P_2O_5, Al_2O_3 and FeO determined in it gravimetrically (analysis II) as a control on the other analysis.

	I.	II.			Ratio calculated from analysis I.
P_2O_5	30·19	29·98	·212		1.
Al_2O_3	21·17	21·44	·208		·98
FeO	26·54	26·20	·368		
MnO	4·87		·069	·458	2·16
CaO	1·21		·021		
H_2O	15·87		·882		4·16
Quartz	·10				
	99·95				

The above ratio corresponds closely to the following:

$P_2O_5 : Al_2O_3 : RO : H_2O = 1 : 1 : 2 : 4$ (R=Fe, Mn, and Ca),

and to the empirical formula $R_2Al_2P_2O_{10}, 4H_2O$, which may be written

$$Al_2P_2O_8 + 2R(OH)_2 + 2aq \text{ or } \left.\begin{matrix} R_3P_2O_8 \\ Al_2P_2O_8 \end{matrix}\right\} + \left.\begin{matrix} R(OH)_2 \\ Al_2(OH)_6 \end{matrix}\right\} + 4aq,$$

or the same as that made out for eosphorite.

The formula in this case corresponds to the following percentage composition: P_2O_5 30·80, Al_2O_3 22·31, FeO 26·37, MnO 4·87 H_2O 15·65=100. This agrees satisfactorily with analysis I.

Note on the relation between Childrenite and Eosphorite; by GEORGE J. BRUSH and E. S. DANA.

In our former paper, to which Mr. Penfield refers, we showed that childrenite and eosphorite were crystallographically closely homœomorphous. Thus the axial ratios for the two species are:—

	c (vertical).	*b* (macrodiagonal.).	*a* (brachydiagonal).
Childrenite, Tavistock (Cooke)	0·667	1·294	1·000
Eosphorite, Branchville	0·663	1·287	1·000

We showed also that the two species were *related* in chemical composition, although there was a wide variation between the results of analysis in the two cases, the formula of eosphorite being clearly established, while that of childrenite was still in doubt. The analysis of Mr. Penfield seems to set at rest the latter question and to show further that the two species have the same formula, but differ in this: that childrenite contains chiefly iron (26·54 FeO, 4·87 MnO) and eosphorite chiefly manganese (7·40 FeO, 23·51 MnO). Eosphorite then should be considered merely as a sub-species under childrenite, related to it in the same way that the lithiophilite from the same locality is to triphylite. The points of difference between the two minerals in physical characters and mode of occurrence have been mentioned in our former paper, and need not be here repeated.

ART. XL. — *Observations on the Planet Lilaea;* by Professor C. H. F. PETERS. (Communication to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., March 6, 1880.)

OF a planet detected on Feb. 16, I communicate the following observations, all that have been hitherto obtained.

1880.	Ham. Coll. m. t.	α (213)	δ (213)	No. of comp.
Feb. 16.	$14^h30^m52^s$	$16^h51^m44^s{\cdot}51$	$+13°16'7''{\cdot}2$	15 ringmicr.
Feb. 18.	11 29 13	10 50 17·35	13 29 18·6	3 ringmicr.
Feb. 19.	14 26 54	10 49 23·97	13 37 11·6	12 ringmicr.
Feb. 27.	8 26 29	10 43 4·67	14 30 47·2	10 fil. micr.
Mar. 2.	9 2 39	10 39 43·29	14 57 26·2	10 fil. micr.

The observation of Feb. 18 is a very indifferent one, and, besides, the comparison star of that day is only approximately determined in zones. The planet appeared of the 11th magnitude. It has received the name *Lilaea.*

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *Photographs of Star Spectra.*—Mr. W. HUGGINS in a note to the French Academy gives some results of his late investigations on stellar spectra. The telescope employed had a metallic mirror; and the spectroscope consisted of a prism of Iceland spar and two quartz lenses. Its slit was about one-fourteenth of a millimeter in width. The spectroscope was fixed upon the telescope so that this slit was precisely at the focus of the reflecting mirror of the telescope; and a special arrangement kept the

image of the star upon the slit during the time of the exposure of the negative. The slit was also made in two halves which made it possible to photograph the solar spectrum, or that from any source of light, just above the spectrum of the star under examination. The photographs obtained were only $0^m{\cdot}013$ in length from G to O in the ultra violet; but the definition was so perfect that at least seven fine lines between H and K in the solar spectrum could be counted. The measurement of the lines was made by a microscope provided with a micrometer and the wave lengths were determined by a graphical method by the aid of Cornu's map of the ultra violet rays of the solar spectrum, and Mascart's table of wave lengths of the cadmium lines. Six spectra obtained belong to the white stars of the type of Vega. All the stars of this type give spectra of essentially the same type. The typical lines consist of twelve very large lines nebulous at their edges. The two less refrangible lines of this group coincide with the hydrogen lines $\lambda=4340$ (near G) and $\lambda=4101$ (h), the third line with H of the solar spectrum. The strong line K of the solar spectrum in only represented by a fine line, and even this line appeared to be absent in Sirius and in η of the constellation of the Great Bear. The lines H and K of the solar spectrum coincide with two bright lines of calcium and are attributed to its vapor. It is important to notice, however, that another pair of more refrangible lines of calcium, $\lambda=3736{\cdot}5$ and $\lambda=3705{\cdot}5$ on Cornu's map do not coincide with the strong lines in these stars. The relative position of these twelve lines are in a certain sense symmetrical. Each pair of lines nearing each other the more refrangible they are. They seem, therefore, to belong to one body. Mr. Huggins' note contains a table of the wave lengths of these twelve typical lines. He finds that in the most typical stellar spectra the continuous spectrum can be traced beyond S; but there are no lines more refrangible than $\lambda=3699$ to be seen. As the star approximates to the solar type, the twelve typical lines become smaller and less nebulous at their edges; other lines present themselves and the line, which corresponds to K in the solar spectrum, becomes large and nebulous. In the spectrum of Arcturus, however, the line K is larger than in the solar spectrum, and the whole extent of the photograph of the spectrum is full of fine and broken lines. The photographic spectra of Jupiter, Mars and Venus give no evidence of change due to the atmospheres of these planets, and the photographs of portions of the Moon's surface under different conditions of illumination also give the same negative result. Mr. Huggins is about to apply his method to the spectra of gaseous nebulæ and to different parts of the solar spots.—*Comptes Rendus*, No. 2, Jan., 1880, p. 70. J. T.

2. *Direct measure of the work of Electrical Induction.*—Herr A. von Waltenhofen, guided by the principle that the work which a current of electricity, from a battery, affords in a conductor must be equal to the work which it is necessary to exert

in order to produce the same current by means of induction, has been led to a determination of the mechanical equivalent of heat. He made use of the magneto-electric machine of constant current of Siemens and Halske, which is described in the twelfth volume of Carl's Repertorium. A dynamometer for estimating the work done in rotating the armature of the machine is described by the author at some length. It is found that 0·13 *mkg* (in round numbers) is the value of the induction work per second in order to produce the electromotive force of one Daniell cell in a circuit of 1 S.E resistance. To produce the electromotive force of one Bunsen cell, 0·4 *mkg* is necessary. Reckoning a horse power at 75 *mkg*, the expression $0{\cdot}0053\,\frac{n^2}{w}$ represents the induction work necessary to produce an electromotive force of n Bunsen cells, through a resistance of w S.E. To this must be added the useless work. According to W. Thomson and Jenkin, a Daniell cell in circuit of one unit resistance affords in each second a quantity of heat represented by the number 0·00030633; by comparing the value 0·13 *mkg* or more exactly 0·13109 *mkg* with this result, Von Waltenhofen finds 427·94 for the mechanical equivalent of heat. Under other conditions of work, the numbers 421·21 and 420·6 are obtained.—*Annalen der Physik und Chemie*, No. 1, 1880, p. 81. J. T.

3. *Mechanical Equivalent of Heat.*—In the proceedings of the American Academy of Arts and Sciences, Part I, 1879, is an exhaustive memoir upon thermometry and the mechanical equivalent of heat, by Professor Rowland of the Johns Hopkins University, Baltimore, Maryland. No treatise on the measurement of heat has appeared which is more valuable than this. The results obtained by Professor Rowland for the mechanical equivalent of heat differ from those of Joule only one part in 430. The investigation also showed a decrease in the specific heat of water as the temperature rises. Complete details are given of the apparatus employed. J. T.

4. *A Dispersion Photometer.*—Messrs. Perry and Ayrton describe a new photometer for measuring very strong light. The light is made to pass through a concave lens and is thus dispersed at a short range over a large surface. The authors believe that the amount of light absorbed by the lens can be accurately estimated, and think that measures can be made more accurately in this way than in the methods of measuring lights from a great distance.—*Phil. Mag.*, Feb., 1880, p. 117. J. T.

II. Geology.

1. *The present state of the Evidence bearing upon the Question of the Antiquity of Man;* by T. McK. Hughes, M.A., Woodwardian Professor of Geology, Cambridge. (Read before the Victoria Institute, 1879).—The following paragraphs, discussing the evidence as to Man's existence in or before the Glacial era in

Europe, and the remarks succeeding, by Professor Dawkins, are cited from a paper bearing the above title.

We may dismiss at once the case [of supposed human remains], reported from the Dardanelles, of works of art found in deposits said to be of Miocene age. The descriptions* prove that it was not given on the authority of one competent to judge in such a case, and it never has been confirmed.

In beds said to be Miocene, at Thenay, near Pontlevoy, the Abbé Bourgeois found flints which he supposed were dressed by man. These flints are now exhibited in the Museum at St. Germains, where I saw them with Sir Charles Lyell several years ago, and again with others since. Some of them seemed entirely natural, common forms, such as we find over the surface everywhere, broken by all the various accidents of heat and frost and blows. A few seemed as if they might have been man's handiwork,—cores from which he had struck off flakes such as we know were used by early man, of which I show examples. Yet this is not quite clear, for, had the evidence been good that they were found in place there still would have been a doubt whether they were man's work. But when we came to inquire about the evidence that they occurred in beds of Miocene age, we learned that only those that we put down as natural were found by the Abbé himself; the others were brought in by workmen, picked up, we may suppose, upon the heaps turned over by their spades, and so perhaps just dropped down from the surface.

Next in the Crag the teeth of sharks, bored through, as if for wear, were found,† part of a string of ornaments such as commonly are worn by savages. Of these I give examples: one a boar's tusk, from the lake dwellings of Switzerland; another, a tooth from a deposit of palæolithic age, in a cave just above the miraculous grotto of Lourdes in the Pyrenees. I have examined fragments of bone and teeth [from the Crag] of various sizes and shapes, and found them marked over the surface with many a pit or deeper hole, or even perforation irregularly placed, not as if by design, but accident. There they were in every stage, all over, yet of one type. One sawn across explains the whole. The chamber of a shell which bores its way into the solid rock or softer shale was clearly shown. When the mass lay embedded in the mud it was but touched here and there. If it was thin the animal bored through into the sand or clay below, piercing the tooth quite through—a perfectly well-turned and finished work, so good it was thought to be man's. But if the mass was thick and near the surface, the little mollusk made a home entirely within it, and its shell often remains there, and reveals the history and manner of formation of the holes.

An account has also been given by the Abbé Bourgeois of flints from Pliocene beds at St. Prest, near to Chartres, said to be

* Journ. Anthrop. Inst., vol. iii, p. 127, April, 1873.
† Journ. Anthrop. Inst., vol. ii, p. 91, April, 1872.

worked by man, but this we may dismiss on the same ground as those before referred to given on the same authority.*

Another case brought forward from abroad but recently, has found much favor here as there.† Around the Lake of Zurich there are left traces of ancient lakes at somewhat higher levels. A bed of clay below with glacial stones, a bed of plants between half-turned to coal, a mass of clay moraine-like on the top, tell of the time when Alpine ice crept farther down the hills, and touched upon the lake, now more, now less encroaching. In these beds the peaty mass of lignite, known as Dürnten coal, was largely dug for fuel. I have worked a long time down below to see the evidence myself. The sequence of the beds is clear. But recently two Swiss professors have proclaimed that they have obtained proofs incontestable that man was there, and wove a basket, fragments of which were found among the drifted plants which formed the coal. These fragments, it is said, consist of pointed sticks, sharpened across the grain, not tapering naturally, and a cross set of binding withes, all now pressed and changed, but by such characters referred to work of man. Now I have found myself along the shore fragments of wood and twigs half decomposed and waveworn till they were cut to a point obliquely to the grain, as they describe the Dürnten sticks. Across such fragments often others fell, and when the whole was then compressed what wonder if they left a mark of wattle or of basket-work? and the whole mass has suffered such great pressure from the superincumbent weight of clay that all the round twigs and stems are squeezed quite flat, as in the specimens before you. These Dürnten pointed sticks, however, I have not seen, and, therefore, speak with caution, showing only how I think the thing might be otherwise explained.

Widespread beds of loam and sand, and gravel, cover the lower levels of East Anglia; and, probably ranging over a vast period, have been collectively described as "middle-glacial," for below are glacial beds, and in the middle series bowlder clay, and over them, whether in part *remanié* or not, another bowlder clay. Lying in hollows and on the flanks of valleys, cut through this ancient loam and other beds, are river terraces of later date; and these, because in great part made up of the older beds, are like them, and require experience to distinguish. In these old terrace-deposits implements of man's undoubted work have long been found; but recently it has been said that some of these beds belong to the older series.‡ This, then, becomes a matter of opinion. For my part, being well acquainted with the deposits in question, and having listened to the evidence, I give my testimony quite against the Glacial or the inter-Glacial age of any of the beds from which the hatchets came. It is, however, said that

* Bourgeois, Congr. Inter. d'Anthrop., 1867, p. 67.

† Rütimeyer, Archiv. für Anthropologie, 1875; Heer, Primæval World of Switzerland.

‡ Mem. Geol. Surv. Geology of Fenland.

other evidence has since been found, conclusive as to this. I can but criticise that which has been adduced; but I will say that if such has been found and been so long withheld, while there are so many deeply interested, and so many who would like to verify at once and on the ground the statements made, then I do hold that there has not been shown that love of full investigation which is the soul of science.

In many countries where rocks of limestone tower in cliffs and crags above the valleys, and are tapped below by undermining streams, the rain which falls upon the higher ground is lost in cracks and joints, and carries off the rock dissolved in water, which contains a little acid caught by the falling rain or drawn from decomposing plants. The fissures thus enlarged into the gaping chasms called "swallows' holes," the "katabothra" of the Greeks, admit a copious torrent, carrying stones and sand which grind and bruise and open out the jointed rocks into great caves and subterranean courses. These, when tapped at lower levels, are soon left dry, and offer to prowling beasts of prey a safe retreat, and often man availed himself of them, as testify the Adullamites and Troglodytes of every age.

From such a cave up in the crags of Craven some evidence is adduced that man existed far back into Glacial times, and this, perhaps, is the best case that has been urged.* There a large group of animals, such as occur elsewhere along with man, and more doubtfully traces of man himself, were found in beds overlapped by Glacial clay which had sealed up the mouth of the vast den in which these relics lay. This excavation I have watched myself at intervals from the commencement, and I hold that as the cliff fell back by wet or frost, and limestone fragments fell over the cave mouth, with them came also masses of clay, which, since the Glacial times, had laid in hollows in the rock above. We dug and found such there, and, more, I observed that the clay lay across the mouth as though it had thus fallen, and not as if it came direct from Glacial ice that pushed its way athwart the crag in which the cave occurs. It seemed to have fallen obliquely from the side where the fissured rock more readily yielded to the atmospheric waste, so that it somewhat underlay the part immediately above the cave. On the inside the muddy water which collected after flood, held back by all this clay, filled every crevice and the intervals between the fallen limestone rock, while still outside was the open *talus* of angular fragments known as "screes."

These are the most important cases that I know where man has been referred to Glacial or inter-Glacial times; but all, it seems to me, quite inconclusive. On the contrary, there is much in them, and much besides pointing the other way. In support of which opinion I will now offer some independent evidence, showing that some similar beds with man and the beasts that are found with him in earliest times can be proved to be post-Glacial. * * *

* Tiddeman, Brit. Assoc. Reports, 1870–8.

Remarks on the paper of Professor Hughes by Professor W. Boyd Dawkins, F.R.S.—I entirely hold with Professor Hughes in the view which he takes relating to the antiquity of man, and the necessity of looking narrowly into facts bearing on the question. All the alleged cases of the existence of man before the Palæolithic age, on the Continent, seem to me on a careful inquiry to be unsatisfactory. If the flints found at Thenay, and supposed to prove the existence of Miocene man, be artificial, and be derived from a Miocene stratum, there is, to my mind, an insuperable difficulty in holding them to be the handiwork of man. Seeing that no existing species of quadruped was then alive, it is to me perfectly incredible that man, the most highly specialized of all, should have been living at that time. The flints shown in Paris by Professor Gaudry appear to be artificial; while those in the Museum of St. Germains appear to be partly artificial and partly natural, some of the former, from their condition, having been obviously picked up on the surface of the ground. The cuts on the Miocene fossil bones discovered in several other localities in France may have been produced by other agencies than the hand of man.

Nor in the succeeding Pliocene age is the evidence more convincing. The human skull found in a railway cutting at Olmo, in Northern Italy, and supposed to be of Pliocene age, was associated with an implement, according to Dr. John Evans, of Neolithic age. Some of the cut fossil bones discovered in various parts of Lombardy, and considered by Professor Capellini to be Pliocene, are undoubtedly produced by a cutting implement before they became mineralized, a point on which the examination of the specimens leaves me no reason for doubt. I do not, however, feel satisfied that the bones became mineralized in the Pliocene age; and the fact, that only two species of quadruped now alive then dwelt in Europe, renders it highly improbable that man was living at this time. This zoological difficulty seems to me insuperable.

The only other case which demands notice is that which is taken to establish the fact that man was living in the Inter-glacial age, in Switzerland. The specimens supposed to offer ground for this hypothesis consist of a few pointed sticks in Professor Rütimeyer's collection at Basle, of the shape and size of a rather thin cigar, crossed by a series of fibers running at right angles. They appear to me after a careful examination to present no mark of the hand of man, and to be merely the resinous knots which have dropped out of a rotten pine trunk, and survived the destruction of the rest of the tree. As the evidence stands at present, there is no proof, on the Continent or in this country, of man having lived in this part of the world before the middle stage of the Pleistocene age, when most of the existing mammalia were alive, and when mammoths, rhinoceroses, bisons, horses and Irish elks, lions, hyænas, and bears haunted the neighborhood of London, and were swept down by the floods of the Thames as far as Erith and Crayford.

2. *On the Age of the Brazilian Gneiss Series. Discovery of Eozoon;* by ORVILLE A. DERBY, M.S., Rio de Janeiro.—The late Professor Hartt has shown in his work entitled "the Geology and Physical Geography of Brazil," that the whole Brazilian plateau is either composed of, or underlaid by, gneissic rocks, which appear at the surface, forming one or more great mountain chains along the whole Atlantic coast, from the Province of Rio Grande do Sul, to Maranhao. In the provinces of Sao Paulo, Rio de Janeiro, and Minas Geraes, this series forms two detached and parallel chains, separated by the valley of the Parahyba river, and known as the Serra do Mar and Serra da Mantiqueira, which rise to the height of 6,000 feet or more, the latter range being somewhat the higher, the culminating point and highest mountain in Brazil, the Pico de Itatiaia, having a height of 8875 feet. The Serra do Mar, as represented in the Organ Mountains, at Heresopolis, is, according to Professor Agassiz, a sharp anticlinal ridge, the almost vertical beds dipping on each side of the center of the range, an observation which has since been verified by Professor Hartt and myself. Farther west, where crossed by the Dom Pedro II Railroad the same Serra is described by Prof. Hartt as a monoclinal ridge, the beds dipping at a high angle to the northward or toward the Parahyba, there being most probably some repetition in the beds, owing to reversed folds or faults. The Mantiqueira range, according to Professor Hartt's observations at Itatiaia, and my own along the railroad near Barbacena, in Minas Geraes, is also a monoclinal ridge, the beds dipping at a less angle than in the Serra do Mar to the southward or toward the Parahyba. The valley of this river appears, therefore, to be a great synclinal.

The succession of the Brazilian gneisses is, according to the observations of Pissis, Hartt, Liais and myself, (1) Porphyritic or granitic gneiss, with red feldspar; (2) fine-grained gray gneiss, (leptinite of Pissis and Liais), often garnetiferous and schistose; (3) fine-grained schistose gneiss, passing to mica schist, with subordinate beds of quartzite, and an abundance of mineral veins not found in the lower parts of the series. This last, the upper or metalliferous series of Pissis and Liais, prevails in the Mantiqueira range, while the lower divisions predominate in the Serra do Mar and Parahyba valley.

The gneiss series was referred by Professor Hartt to the Archæan, on account of its position beneath the other Brazilian strata, and the striking resemblance with the Laurentian series of North America, this opinion being confirmed by Dr. Sterry Hunt from an examination of the specimens collected by Professor Hartt. At that time no fossiliferous rocks older than the Cretaceous were positively known in the empire. Since then, however, the labors of the members of the Geological Commission have shown that the coal-bearing beds of southern Brazil belong, as was at first supposed, to the Carboniferous, and are underlaid, in the province of Paraná, by beds of Devonian or Upper Silurian age;

and that, on the Amazonas, there is a fossiliferous series consisting of Carboniferous, Devonian and Upper Silurian, resting, unconformably, not on the gneiss, but on an extensive series of quartzites superior to it.

In southern Brazil, at least, limestones are extremely rare in the gneiss series. The only bed definitely known is a thin one in the Parahyba valley, well exposed at the Barra do Pirahy, where it was examined by Professor Hartt and myself. The river, both above and below Barra, flows along the strike of the beds, which is very regularly N. 60° E., the limestone appearing at various points, at, or near the river, until it makes a bend to the eastward and escapes from behind the Serra do Mar, above the city of Campos. This distance is about 120 miles. About 30 miles above Barra, along the line of strike, limestone is reported near Barra Mansa.

It is remarkable that about 100 miles farther to the southwestward, limestone in the gneiss series is reported by Rath near Gnape, in a locality which is almost exactly on the prolongation of the line of strike from Barra.

The bed at Barra is about fifty feet thick, enclosed in schistose, garnetiferous gneiss, and dips 60° to the northward.

The rock is a coarsely crystalline, white marble, showing a beautiful bluish tint when held to the light in thin pieces, and contains a small amount of pale green serpentine, soft and greasy like talc, from decomposition, distributed in thin films along the planes of bedding. The serpentine is not distributed through the mass and nothing resembling Eozoon is to be found. Near the small village of Sta Anna de Pirapitinga, the farthest point to the northeast of Barra, where the limestone is known, I have lately had an opportunity of examining it, through the kindness of my friend, Dr. J. A. de Santos, who called my attention to it. The bed here has almost precisely the same thickness, position and lithological characters as at Barra, and, being on the line of strike of the bed at the latter place, with a number of known localities at intervening points, on or near the same line, where similar rock occurs, I have no doubt of the identity of the bed. The surfaces exposed in the quarry are covered with beautiful foliaceous incrustations of chalcedony, and the small admixture of serpentine, instead of occurring in films, as at Barra, is thickly distributed in small points throughout limited portions of the bed. Specimens of this rock polished and treated with acid, present various appearances described by Dr. Dawson as characteristic of Eozoon.

Note.—Since writing the above, Mr. Derby, in the course of explorations along the Rio Sao Francisco, has discovered a bed of serpentine limestone, in the metamorphic series of the Serra da Carauná, Province of Alagoas, near the falls of Paulo Affonso, which, he says, is very similar in character to that of the Barra do Pirahy and Pirapitinga. A single small fragment of the Pirapitinga limestone, and several larger ones from the beds at Carauná, sent me by Mr. Derby, have been examined by Dr.

Dawson, of Montreal, who kindly furnishes for publication, the following notice regarding their organic contents.—R. RATHBUN.

3. *Note on Limestone from the Gneiss Formation of Brazil;* by J. W. DAWSON, LL.D., F.R.S.—The specimens submitted to me by Mr. R. Rathbun, from the collection of Mr. Derby, are as follows:—

No. 1. Small specimen, which has been etched with acid, and is stated to be from Sta. Anna de Pirapitinga. This specimen consists of dolomite and calcite, white and crystalline, with grains of olive-colored serpentine. It shows some obscure forms which may be organic; but nothing which can be affirmed to be *Eozoon.* The specimen is, however, too small and imperfect to afford any definite information as to its nature and fossil contents.

No. 2. This is a limestone apparently similar to the last, and presumably from the same formation. It is said to be from the Serra da Carauná, Province of Alagôas. As there were several small fragments of this limestone, it was carefully etched with dilute nitric acid. On examination it showed in a few spots groups of canals similar to those of *Eozoon Canadense,* filled with dolomite. These probably represent fragments of *Eozoon.* There is no appearance of lamination, and the rock seems to consist of limestone and dolomite intermixed, and with grains of pale olive serpentine. The rock and its contained fragments of *Eozoon* resemble those of some layers of the limestone of Petite Nation, and also the limestones of Chelmsford, Massachusetts, and of Warren county, New York. I have no doubt that this limestone is of Laurentian age, and partly composed of fragments of *Eozoon,* and think it probable that more extended search may discover in it entire masses of the fossil.

4. *Geological Survey of Alabama; Report of progress for* 1877 *and* 1878; by EUGENE A. SMITH, Ph.D., State Geologist. 140 pp. 8vo. Montgomery, Alabama, 1879.—Dr. Smith commences his valuable Report, with a general sketch of the features and geology of the Basin of the Tennessee, in Northern Alabama, where the coal-measures are the uppermost beds, with the exception of the stratified drift of the valleys. Then follow chapters on the Geology of the Counties which belong to the Tennessee Basin; an account of Brown's Valley, which covers parts of Jackson, Marshall, Cullman and Blount Counties, and geological descriptions of parts of the Warrior Coal-field Basin. The Warrior Coal-field Basin is a southwestern portion of the Cumberland Table-land, so conspicuous a feature in the eastern half of Tennessee. In this basin in Jefferson County, along a ridge in Jones' Valley, dividing it longitudinally, there occurs one of the great faults of the Appalachians, so well marked at the east foot of the Cumberland Table-land in Tennessee. The strata of the Upper Silurian, Devonian and Sub-carboniferous, are brought up by it to a level with a limestone of the Quebec group, and, besides, there is an overturn, the last-mentioned formation overlying, with conformable eastward dip, all the other formations, with the Sub-carboniferous beds

the lowermost. The geology of several of the valleys is illustrated by maps. It closes with a Chemical Report by HENRY MCCALLY, of the University of Alabama, giving analyses of coals and iron ores, and a list of Elevations (with their distances from Memphis), on the Memphis and Charleston railroad.

5. *On Conodonts from the Chazy and Cincinnati Group of the Cambro-Silurian, and from the Hamilton and Genesee-Shale Divisions of the Devonian, in Canada and the United States;* by GEORGE JENNINGS HYDE, Esq., F.G.S., with three plates.—From this interesting monograph, we quote the following clause, giving the general results arrived at:

It has been shown that whilst Conodont teeth do not correspond in minute structure with, and are far more varied in form than, the teeth of any known fish, they yet approach closest to those of the Myxinoids. As it is not at all improbable that there was in Palæozoic times as great a development of the Cyclostome Fishes as of the Ganoids and Elasmobranchs, with a consequent great amount of variation in their structural development, we could hardly judge, from their pauperized descendants of the present day, how far this variation may have extended in former times. We should not, therefore, on account of the imperfect analogy of the Conodonts with the teeth of existing Myxinoids, reject altogether the probability that they may have belonged to a similar low type of Fishes. At present, however, the facts at hand appear insufficient to decide the question.—*Quarterly Journal of the Geol. Society*, Aug., 1879.

6. *Report on the Paleontological Field-work for the season of* 1877; by C. A. WHITE, M.D. (Extracted from the 11th Annual Rep. U. S. Geol. Survey, F. V. Hayden, Geologist-in-charge).—Professor White gives in this Report large additions to the known facts respecting the distribution of fossils of the Fox Hill group of the Upper Cretaceous, and the Laramie (or Lignitic) Group. With regard to the former he gives, in his concluding chapter, tables illustrating the range of the species under columns, headed (1) Upper Missouri region, (2) Eastern Colorado, (3) Northwest Colorado, (4) Coalville in Utah, (and the whole valley of Weber River), (6) Bear River Valley (including also the adjacent portion of Sulphur Creek up to Hilliard Station). A similar table for the Laramie group has for its columns (1) Judith River Beds, (2) Fort Union Beds, (3) Eastern Colorado, (4) Northwest Colorado, (5) Bitter Creek Valley, (6) Bear River Valley. Professor White concludes that the waters of the great Laramie sea were essentially brackish, and that the commingling of fresh water and brackish water species did not arise from fluvial transportation but from their having lived and thrived together.

7. *Cretaceous Fossils of the Western States and Territories*, by C. A. WHITE, M.D. *Contributions to Paleontology.* No. I. (From the 11th Annual Rep. Surv. for 1877, U. S. Geol. Surv., F. V. HAYDEN, Geologist-in-charge).—This Report contains, besides descriptions of numerous species, also many figures of the species on ten plates.

8. *Remarks on the Genus Proterocrinus* of Lyon and Casseday, by A. C. WETHERBY. Journ. Cincinnati Soc. Nat. Hist., April, 1879.

9. *Revision of the Palæocrinoidea.* Part I. *The families Ichthyocrinidæ and Cyathocrinidæ;* by CHARLES WACHSMUTH and FRANK SPRINGER. 153 pp. 8vo, with two plates. Philadelphia, 1879 (from the Proceedings of the Academy of Natural Sciences, Nov. 4, 1879).—A very important contribution to the department of Fossil Crinoids.

10. *Descriptions of New Species of Crinoids from the Kaskaskia Group of the Subcarboniferous;* by A. C. WETHERBY. Ibid., October, 1879.—Professor Wetherby, in these papers, describes in detail from excellent specimens the genus Proterocrinus, and several species of the remarkable crinoids referred to it. The author states that the *Dichocrinus cornigerus* and *D. 6-lobatus* of Shumard cannot be referred to the genus as has been proposed, and that its nearest alliance is with *Eucalyptocrinus.* Four species, *P. bifurcatus, P. acutus, P. spatulatus* and *P. parvus* are beautifully figured on one of the plates.

III. BOTANY AND ZOOLOGY.

1. *Soluble Matter of Soil retained by Vegetation.*—Soil three inches deep was placed in two glazed earthenware pans, 17 inches in diameter, on July 21: four grams of white clover seed was sown in one, the other being blank. The pans were exposed till Oct. 4. The drainage water was collected and analyzed; that from the clover soil contained 48·1 grains of solid matter per gallon; the other 220. The author concludes that rain removes much more matter from an uncropped than from a cropped soil.—*Chem. Soc.*, Jan. 15; from *Nature*, Jan. 22.

2. *Seeds endure extreme Cold.*—CASIMIR DECANDOLLE and RAOUL PICTET, of Geneva, have continued and extended some old experiments upon this subject, the results of which are reported in the Arch. Sci. Phys. & Nat. for Nov. 1879. Seeds of mustard, cabbage, and grains of wheat, without previous desiccation, enclosed in sealed tubes, sometimes mixed with metal filings to ensure complete and rapid refrigeration, were exposed to a temperature of from −50° to −80° centigrade, for from two to six hours, the cold produced by the evaporation of liquid sulphurous acid; the seeds were allowed to regain the ordinary temperature of the air without delay; then, on being sown, they germinated as promptly and well as corresponding seeds not so treated. A. G.

3. *The Genus Ginkgo*, now represented by the single Japanese species, first appears (according to Heer, in Arch. Sci. Phys. & Nat., Dec. 1879), in a single species, in a deposit between the Jurassic and Triassic, and in the Jurassic counted nine species, two of which extended from England to Spitzbergen, while the other seven along with one of the former inhabited eastern

Siberia, one of them reaching Japan, the present home of all that survives of the genus. One or two species are known in the Wealden, and two others in the Tertiary. One of these, known from northern Greenland and from Sachalin, is so near the extant species that it may be united with it. In the Jurassic this genus was accompanied by four other Taxineous genera, one of which (*Baiera*) was continued into the Cretaceous formation; in the Tertiary also by another (*Feildenia*), recently discovered by Nordenskiöld in Spitzbergen. *Cordaites* carries the Taxineous type back to the Carboniferous and the Devonian; so that this group of plants contains the most ancient Phænogams. A. G.

4. *The Floral Development of Helianthus annuus*, by W. H. Gilbrest.—A paper in the Journal of the Quekett Microscopical Club (Oct., 1878), with a plate. The two points of interest relate to the morphological nature of the pappus and of the ovule. The latter develops as if it was the termination of the axis. The two scales of the former, both as to development and structure, should be regarded as foliar (not trichomes), and therefore as answering to calyx; but their development is much later than that of the corolla. The paper is a neat one. A. G.

5. *Morphology of Vegetable Tissues*, by W. H. Gilbrest.—A paper reprinted from the Journal of the Royal Microscopical Society, read Oct. 8, 1879, with two plates, treating the histology of the Cambium, in several Dictyledonous trees and shrubs; summed up by the author thus:

. . . . "It appears that the cambium layer is not a portion of the procambium remaining over after the differentiation of the primary phlœm and xylem, but a special and new tissue developed from it. . . . . That the cambium is composed of prosenchymatous cell-groups; . . . . on the phlœm side parenchyma is produced by the rounding off and sometimes by the further division of the individual cells, and prosenchyma on the xylem side by the absorption of the transverse septa; wood-parenchyma being simply those cambium cell-groups in which such absorption has not taken place. That the vessels arise by fusion of certain cambium cell-groups, which are arranged vertically, and the oblique septa separating the groups being partly absorbed, and the transverse ones entirely so. That absorption of the oblique septa appears to commence with the formation of sieve-plates, the pores of which enlarge and coalesce till there is either one large circular aperture through the center, or the bands dividing the sieve-plates remain, forming the scalariform septa of some species." A. G.

6. *Aroideæ Maximilianæ, die auf der Reise Sr. Majestät des Kaisers Maximilian I, nach Brasilien gesammelten Arongerwächse nach handschriftlichen Aufzeichnungen von H. Schott beschrieben von* Dr. J. Peyritsch. (Wien: Gerold's Sohn, 1879.) —This is an imperial folio volume, sumptuously illustrated with forty-two plates of new *Aroideæ*, and a frontispiece of Aroideous Vegetation, done in chromolithography. It is the best chromo-

lithography we have seen. The copious details, most admirably drawn, are also printed in colors and are very effective. The letter-press is equally superb. It was in part prepared by Schott, the first monographer of the *Aroideæ*, who died in 1865, was then taken in hand by Kotschy, who died soon after, and by Fenzl, whom we have recently lost, and is now completed by Dr. Peyritsch. This magnificent book is the latest and probably the last of the fruits of the voyage to Brazil (in 1859–60) of the unfortunate Maximilian. We suppose it is brought out by his executors, and is a monument to his memory. A. G.

7. *Naturalized Weeds and other Plants of South Australia*, by RICHARD SCHOMBURGK, Ph.D., etc. Adelaide, 1879. 4to pamphlet.—It was a good thought to make a record of the troublesome plants already naturalized in South Australia, with as far as possible the dates and particular circumstances of their introduction, and thus to give succeeding observers the means of comparing the future with the present condition. It will be interesting to know whether the species most aggressive up to this time will continue predominant, or whether they may either lose their exceptional vigor or be checked at length by other competitors. The race is not always to the swift, if it be a long one. Most of the introduced weeds came from Europe. The following are exceptions:

Oxalis cernua of the Cape of Good Hope. This arrived as a garden plant, near the year 1840; it now overruns all gardens, and is spreading most alarmingly in the wheat fields. It is said that the first bulbs were sold for two pence each. It now has notorious preëminence over all introduced weeds, since it is next to impossible to eradicate it when it has obtained a footing.

Cryptostemma calendulacea, called Cape Dandelion, "has taken possession of the land for the last twenty-five years, and grows as vigorously as ever," covering even the mountain ranges, when untimbered, to their summits. It is an annual, and is much liked by cattle and sheep, so that it is not so much of a nuisance.

The next are mostly common weeds of Southern Europe, but many of them came in by way of Tasmania. The worst are *Compositæ*, and are mainly Cockspur or *Centaurea Melitensis*, Bathurst Bur or *Xanthium spinosum*, Scotch Thistle or *Onopordon Acanthium*, *and Inula suaveolens*, called Stink-Aster, "the most noxious and dangerous plant ever introduced." An equally bad character is given to the Black Oat, *Avena sativa*, var. *melanosperma*, which is singular, considering that its near relative, the *Avena sterilis*, is a great blessing to California, over which it has been widely diffused. Dr. Schomburgk says: "The Black Oat has the most notorious preëminence of all the introduced weeds, and the effects of this intruder are most ruinous to the farming community. . . . . Thousands of acres of arable land, especially such as have been in cultivation for some years, are totally ruined for the purpose of wheat-growing by the black oats."

A dozen and a half of other grasses which occur in the list "are less dangerous to cultivation, in fact they have improved the native pasture near the coast materially," and the same is said of the *Leguminosæ*, which are Clovers, Melilots, and Vetches.

A glance at the list of weeds throughout does not favor the idea that they owe their predominance in any perceptible degree to self-fertilization. *Oxalis cernua* propagates by its bulbs, and so may be ranked with self-fertilized plants by analogy; but the blossoms have provision for cross-fertilization. All except the grasses and four or five Dicotyledons are coroliferous, and most of them insect-visited. A. G.

8. *Canadian Timber-trees, their Distribution and Preservation;* by A. T. Drummond.—An instructive pamphlet, published at Montreal in 1879, being a Report to the Montreal Horticultural Society, accompanied by a map (by Dr. Bell and Mr. Drummond) marking the northern limit of the principal forest trees of Canada and Nova Scotia. There are sixty-five species of trees in this district; but only the most important ones are specified. More stringent laws are recommended for the prevention of forest fires, which in Canada, as elsewhere, are the crying evil. The fact that the jutting headlands of Lake Superior have a semi-arctic vegetation, while the bordering district to the northward has the common cool temperate flora, is alluded to. It is attributed to the moist, cool, but equable atmosphere, resulting from the presence of such a large body of deep water, retaining here the vegetation of an older and cooler period. But the sweep of winds, keeping back the forest, may also be considered. A. G.

9. *Indian Corn;* by E. Lewis Sturtevant, M.D. A paper presented to the Annual meeting of the New York State Agricultural Society, January 1879, and reprinted from its 38th Annual Report.—The history of Maize is detailed with considerable fulness, and the opinion is hazarded that the plant may have reached Europe by grain brought by the Northmen in the eleventh century, and by them have been transferred to the Levant. But there seems to be no proof that the plant had reached Turkey before the time of Columbus. The principal varieties of Indian cultivation are enumerated and the variations of ordinary cultivation are classified. The number of rows of grain on the cob vary from 8 to 36, and nearly all are in even number of rows; but odd numbers are not uncommon and perhaps prevalent in the maize of the Incas or of earlier South American races, preserved with mummied Indians. A section of Hybridizing adduces original observations in confirmation of the action of the pollen of one variety in directly altering the grain of another; and this influence is said to affect not only the coats of the grain but the nature and appearance of the kernel. A G.

10. *Death of General Munro.*—With sadness we hear that Gen. Wm. Munro, of the British army, the most accomplished Agrostologist of our day, died at his residence near Taunton, on the 29th day of January. He had reached the age of about 64 years, and

of late his health had deteriorated to an extent that gave his friends concern. But it was thought his valuable life might be prolonged so that he could achieve the great work upon which his heart was set and the hopes of botanists centered, viz., the *Species Graminum*. Although until recently his studies in botany were pursued in the precarious intervals of an active professional life, necessitating frequent changes of abode under widely different climates, he had mastered his favorite department, so that no one living knew grasses so well, or was so competent to treat the whole order systematically. Of independent publication he had done little, except to bring out a monograph of the bamboo tribe, which shows what he was capable of. But upon the retirement from active service, with honors well earned by arduous and splendid service, he devoted the remainder of his life to a revision of all grasses, which was to form two volumes of DeCandolle's *Monographiæ Phenogamarum*.* Alas, it was too late. But perhaps the monograph of the *Puniceæ* may have been nearly completed. Yet the great *desideratum* of botanists remains, and their hopes are dashed on the eve of expected fulfillment. Personally, Gen. Munro was greatly respected, trusted, and beloved. The very distinct genus which commemorates his botanical services, *Munroa squarrosa* of Torrey, is one of the Buffalo grasses of our western plains.* A. G.

11. *Crustacea of Mexico and Central America.*—Mission Scientifique au Mexique et dans l'Amérique Centrale, publié par ordre du Ministre de l'Instruction Publique. *Etudes sur les Xiphosures et les Crustacés de la Région Mexicaine*, par M. Alphonse Milne Edwards. 4to, Paris: 4e livraison, pp. 121–184, 9 plates, 1878; 5e et 6e livraisons, pp. 185–264, 19 plates, 1879.—The earlier parts of this magnificent work were noticed in vol. xi of this Journal (p. 329, 1876). In the last three parts the account of the Maioidea is completed and that of the Cancroidia begun; the fourth part contains the last of the Mithracinæ, the Micippinæ, Libininæ, Amathinæ, Epialtinæ, Parthenopinæ (including *Œthra*) and part of the Leptopodinæ; the fifth part completes the last family and, with a short supplement, the Maioidea, and begins the Portuniens, which are completed and the Canceriens well begun in the sixth part. Though, upon the groups of which it treats, already by far the most extensive and important work appearing within twenty years, it seems thus far to have escaped notice in the Zoological Record. It deserves a more extended notice than the space at my disposal in these pages permits.

The nine families of Oxyrhynques (Maioidea) include 58 genera and 150 species; 11 of the genera and 30 of the species are new, and over 80 of the species are figured. The Portuniens include 9 genera and 28 species, 1 genus and 3 species being new, and half the species are figured. The generic grouping of the Portu-

* Published in the fourth volume of the U. S. Pacific Railway Expedition Reports; erroneously printed *Monroa*. There is also a mistake in saying that Col. Munro was in the East India Company's service, though he served long and bravely in India.

nidæ is considerably modified from that adopted by the same author in his monograph of the group published in 1861, so that the genera are nearly the same as used by Stimpson. *Callinectes* is admitted but all the forms described by Ordway are reduced to varieties of a single species and a number of new varieties are described. The old name *diacanthus* is restored for the polymorphic species thus constituted, but the varietal names are printed in the same way as the specific, so that under the species "*Callinectes diacanthus*" we have the variety "*Callinectes diacanthus* (Ordway)," which is certainly confusing. *Cronius* is adopted, but *Arenæus* is still retained under *Neptunus*. The Canceriens as far as treated include 13 genera and 29 species; 2 genera and 1 species are new, and 19 species are figured.

The plates are admirable and are crowded with most excellent figures, of which several are usually given for each species. Some of the plates on which the larger of the species are represented are lithographic and two of these in the sixth part are colored, but the great majority of the plates are engraved in the finest manner on metal. S. I. SMITH.

12. *U. S. Commission of Fish and Fisheries. Report of the Commission for* 1877. Part V. Washington, 1879. 8vo. 981 pp., numerous plates.—This volume includes in the general report of Professor S. F. Baird, the Commissioner, a statement of the results accomplished both in the way of exploration and in the propagation and introduction of food-fishes, and the participation of the Commission in the Fishery Convention at Halifax. Several hundred pages are occupied by a thorough history of the menhaden and the fisheries and manufactories dependent upon it, by Mr. G. Brown Goode. Among the other papers is one by Karl Dambeck, on the distribution of the cod family; on the cod fisheries near the Loffoden Islands, by G. O. Sars; on the salt water fisheries of Norway, by G. O. Sars; several reports on the artificial propagation of various fishes; on the Miller Cassella thermometer, by Commander L. A. Beardslee; on artificial refrigeration, by John Gamgee. V.

13. *American Fisheries. A History of the Menhaden, by* G. Brown Goode, *with an account of the Agricultural Uses of Fish;* by W. O. Atwater. 8vo. 529 pp., 30 plates. New York: Orange Judd Company, 1880.—This is a separate edition of Mr. Goode's report, included in the preceding, with additions bringing the subject down to date. V.

14. *The Chinch Bug (Blissus Leucopterus): Its history, characters and habits and the means of destroying it or counteracting its injuries;* by Cyrus Thomas, Ph.D. With a map showing the distribution. 44 pp. Washington, 1879 (U. S. Entomological Commission, Bulletin No. 5).

IV. Miscellaneous Scientific Intelligence.

1. *Vesuvius.*—In Nature (xxi, p. 351), Mr. G. F. Rodwell summarizes the history of the volcanic action of Vesuvius in the last year. During 1879, small streams of lava appeared at intervals on the sides of the great cone, and on December 17, a stream reached to the Atrio del Cavallo. On January 13, 1880, he ascended the cone, although with difficulty on account of the violent and cold wind which prevailed. The small inner cone had increased since his ascent of the previous year, and now reached more than fifty feet above the rim of the great crater, which moreover was almost filled up by lava and scoriæ.

The cone of November, 1878, was giving off dense volumes of steam and smoke and seemed to be full of lava. Near its base was an opening, "apparently about five feet in diameter," through which there had been recent outflows, and while he was watching it, a stream of lava issued forth, which soon after flowed over the rim of the great crater in a stream 25 feet wide, and before next morning had reached the same extent as on December 17. A private letter from a gentleman, who ascended to the lip of the crater on February 2, speaks of a small eruption two days before, which had filled the crater and overflowed exactly in the direction of the top of the railroad which is being constructed up the cone, and nearly reached the place staked out for the station. From the lower part of this stream the lava was still advancing at the rate of about a foot a minute. In regard to the future, Professor Palmieri says, "This long and mild eruptive period will not in our opinion come to an end without displaying more decided activity. The whole history of Vesuvius may be divided into periods of activity, with occasional phases of violence, and short intervals of rest. And the greatest eruptions have generally indicated the last phase of long periods of moderate activity." C. G. R.

2. *The Study of Earthquakes in Switzerland.*—The Commission on this subject, appointed at the meeting of Swiss Naturalists in 1878, consisting of Professor Foster of Bern as President, Professor A. Heim of Zurich, Secretary, with Professors Amsler, Forel, Hagenbach and Soret, and M. Biswiller, has perfected a schedule of operations. It is proposed to provide two or three chief stations (Bern, Basel, and if possible Geneva) with first-class seismometers, and then to organize a wide set of second-class stations with simpler instruments. For the latter there are three propositions, two being modifications of the pendulum and mercury seismometers, and the third, essentially the row of graduated cylinders suggested by Mallet. They are to be submitted to experiment to determine the most desirable. Besides this, as tending to interest the public in such observations, Professor Heim has published a pamphlet on the nature and causes of earthquakes, and on the means of observing them without instruments. This pamphlet, which will be translated into French, is to be widely distributed.

Further, the whole country is divided into seven regions, one being assigned to each member of the Commission, who, on the occurrence of an earthquake in his section, will at once send printed lists of questions in regard to it to all persons likely to give information. The replies will of course become matter of record. If this well-laid plan is carried out, it is likely to afford extensive and valuable information in regard to Swiss earthquakes, and to aid greatly in the general study of the subject.—*Abstract from Nature.* C. G. R.

3. *On the Figure of the Earth.*—In a paper by Colonel A. R. CLARKE on the figure of the earth, published in the Philosophical Magazine, for January, 1878 (p. 81), the following values are given for the dimensions of the terrestrial ellipsoid:—

a=20926629 feet. b=20925105 feet. c=20854477 feet.

Here a and b are the equatorial radii, and c the polar radius.

The ellipticities of the two principal meridians of the earth (i. e. the ratio of the difference of the semi-axes to half their sum) are:— $\frac{1}{289{\cdot}54}$ and $\frac{1}{295{\cdot}77}$.

Col. Clarke adds:—"The longitude of the greater axis of the equator is 8° 15′ west of Greenwich, a meridian passing through Ireland and Portugal, and cutting off a portion of the northwest corner of Africa; in the opposite hemisphere this meridian cuts off the northeastern corner of Asia, and passes through the southern island of New Zealand. The meridian containing the smaller diameter of the equator passes through Ceylon, on the one side of the earth and bisects North America on the other. This position of the axis, brought out by a very lengthened calculation, certainly agrees very remarkably with the distribution of land and water on its surface."

The values of Listing corresponding to the above, quoted from the Astronomische Nachrichten in this Journal, vol. xvii, p. 74, Jan., 1879) (employed by Todd, l. c. xix, 62, Jan., 1880), are not well founded and should not be accepted.

4. *Metallurgy: the art of extracting metals from their ores;* by JOHN PERCY, M.D., F.R.S., etc. *Silver and Gold.* Part I. 698 pp. 8vo. London, 1880 (J. Murray).—This is the first part of the fifth of the series of volumes upon metallurgy by Dr. Percy. These volumes form distinct, and in a measure, independent treatises. The present volume shows the same careful and scholarly treatment that has characterized the previous works by this author. It contains a chapter of over two hundred pages on the physical and chemical properties of silver and its alloys, with a description of all the known minerals containing silver. This is followed by a very complete account of the methods and apparatus used in the assaying of silver (75 pages); the separation of silver from copper by the liquation process (195 pages); smelting of ores containing silver chiefly in the metallic state and the combined silver and lead smelting (52 pages); concluding with amalgamation, or the extraction of silver from its ores by means of mercury

(104 pages). This last section covers only the Mexican or *patio* process as practised in Mexico and South America. The second part of this volume, a portion of which is already in type, will be awaited with interest, as it will contain a discussion of the pan-amalgamation as practised in the United States, and complete the metallurgy of silver and gold. It will be remembered that Dr. Percy's volume on Lead contained much relating to the metallurgy of silver.

5. *An historical sketch of Henry's contribution to the Electro-magnetic Telegraph; with an account of the origin and development of Professor Morse's invention*, by WILLIAM B. TAYLOR. 103 pp. 8vo. Washington, 1879.—This pamphlet is reprinted from the Smithsonian Report for 1878. It contains a well-digested account of the successive steps in the development of the electric telegraph, from the middle of the eighteenth century, down. It has special reference, however, to the very important contributions of Professor Henry toward its practical establishment and final success.

6. Bulletins of the United States National Museum. The following are the contents of numbers recently issued:

NO. 12. Contributions to North American Ichthyology, No. 3; A: On the distribution of the Fishes of the Alleghany Region of South Carolina, Georgia, Tennessee, with description of new or little known species, by D. S. Jordan and A. W. Brayton; B: A synopsis of the Family Catostomidæ, by D. S. Jordan. 237 pp. Washington, 1878. NO. 13. The Flora of St. Croix and the Virgin Islands, by Baron H. F. A. Eggers. 133 pp., 1879. NO. 14. Catalogue of the Collection illustrating the animal resources and the fisheries of the United States, prepared under the direction of G. Brown Goode. 351 pp., 1879. NO. 15. Contributions to the Natural History of Arctic America made in connection with the Howgate Polar Expedition, 1877–78, by Ludwig Kumlien, Naturalist of the Expedition, 179 pp., 1879.

7. *Transactions of the Connecticut Academy of Arts and Sciences*, Vol. V, Part I, 257 pp. 8vo, with 24 plates. New Haven, 1880. The contents of the volume are as follows:—

Synopsis of the Pycnogonida of New England, by Edmund B. Wilson, with plates 1 to 7; The Stalk-eyed Crustaceans of the Atlantic Coast of North America north of Cape Cod, by S. I. Smith, with plates 8 to 12; A list of the Brazilian Echinoderms, with notes on their distribution, etc., by Richard Rathbun; The Comet of 1771: investigation of its orbit, by William Beebe; The Cephalopods of the Northeastern coast of America, by A. E. Verrill, with plates 13 to 25.

Reports on the Results of Dredging under the supervision of Alexander Agassiz in the Gulf of Mexico, 1877-78, by the U. S. Coast Survey Steamer "Blake," Lieut.-Commander C. D. Sigsbee, U. S. N. commanding. V.—General conclusions from a preliminary examination of the mollusca, by W. H. Dall. (Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass., vol. vi, No. 3).

APPENDIX.

ART. XLI. — *On the Efficiency of Edison's Electric Light;* by Professor H. A. ROWLAND of the Johns Hopkins University, and Professor GEORGE F. BARKER of the Univ. Pennsylvania.

THE great interest which is now being felt throughout the civilized world in the success of the various attempts to light houses by electricity, together with the contradictory statements made with respect to Mr. Edison's method, have induced us to attempt a brief examination of the efficiency of his light. We deemed this the more important because most of the information on the subject has not been given to the public in a trustworthy form. We have endeavored to make a brief but conclusive test of the efficiency of the light, that is, the amount of light which could be obtained from one horse power of work given out by the steam engine. For if the light be economical, the minor points, such as making the carbon strips last, can undoubtedly be put into practical shape.

Three methods of testing the efficiency presented themselves to us. The first was by means of measuring the horse power required to drive the machine, together with the number of lights which it would give. But the dynamometer was not in very good working order, and it was difficult to determine the number of lights and their photometric power, as they were scattered throughout a long distance, and so this method was abandoned. Another method was by measuring the resistance of, and amount of current passing through a single lamp. But the instruments available for this purpose were very rough, and so this method was abandoned for the third one. This method consisted in putting the lamp under water and observing the total amount of heat generated in the water per minute. For this purpose, a calorimeter, holding about $1\frac{1}{4}$ kil. of water, was made out of very thin copper: the lamp was held firmly in the center, so that a stirrer could work around it. The temperature was noted on a delicate Baudin thermometer graduated to $0°{\cdot}1$ C.

As the experiment was only meant to give a rough idea of the efficiency within two or three per cent, no correction was made for radiation, but the error was avoided as much as possible by having the mean temperature of the calorimeter as near that of the air as possible, and the rise of temperature small. The error would then be much less than one per cent.

A small portion of the light escaped through the apertures in the cover, but the amount of energy must have been very minute.

In order to obtain the amount of light and eliminate all changes of the engine and machine, two lamps of nearly equal power were generally used, one being in the calorimeter while the other was being measured. They were then reversed and the mean of the results taken. The apparatus for measuring the light was one of the ordinary Bunsen instruments used for determining gas-lights, with a single candle at ten inches distance. The candles used were the ordinary standards burning 120 grains per hour. They were weighed before and after each experiment, but as the amount burned did not vary more than one p. c. from 120 grains per hour, no correction was made.

As the strips of carbonized paper were flat, very much more light was given out in a direction perpendicular to the surface than in the plane of the edge. Two observations were taken of the photometric power, one in a direction perpendicular to the paper, and the other in the direction of the edge, and we are required to obtain the average light from these. If L is the photometric power perpendicular to the paper, and l that of the edge, then the average λ will evidently be very nearly

$$\lambda = \mathrm{L}\int_{\frac{1}{2}\pi}^{0} \cos\alpha \sin\alpha \, d\alpha + l\int_{\frac{1}{2}\pi}^{0} \sin^2\alpha \, d\alpha$$

$$\lambda = \tfrac{1}{2}\,\mathrm{L} + \frac{\pi}{4} l$$

In the paper lamps we found $l = \frac{1}{3}\mathrm{L}$ nearly; hence $\lambda = \frac{8}{4}\mathrm{L}$ nearly.

The lamps used were as follows:

No.	Kind of carbon.	Size of carbon.	Approximate resistance when cold.
580	paper	large	147 ohms.
201	"	"	147 "
850	"	small	170 "
809	"	"	154 "
817	fiber	large	87 "

The capacity of the calorimeter was obtained by adding to the capacity of the water, the copper of the calorimeter and the glass of the lamp and thermometer. The calorimeter and cover weighed 0·103 kil. and the lamps about 0·035 kil.

First experiment, No. 201 in calorimeter and No. 580 in photometer; capacity of calorimeter $= 1{\cdot}153 + {\cdot}009 + {\cdot}007 = 1{\cdot}169$ kil. The temperature rose from 18°·28 C. to 23°·11 C. in five minutes, or 1°·75 F. in one minute. Taking the mechanical equivalent as 775·, which is about right for the degrees of this thermometer, this corresponds to an expenditure of 3486 foot pounds per minute. The photometric power of No. 580 was 17·5 candles maximum, or 13·1 mean, λ.

When the lamps were reversed, the result was 3540 foot pounds for No. 580, and a power of 13·5 or 10·1 candles mean. The mean of these two gives, therefore, a power of 3513 foot pounds per minute for 11·6 candles, or 109·0 candles to the horse power.

To test the change of efficiency when the temperature varied, we tried another experiment with the same pair of lamps, and also used some others where the radiating area was smaller, and, consequently, the temperature had to be higher to give out an equal light.

We combine the results in the following table, having calculated the number of candles per indicated horse power by taking 70 per cent of the calculated value, thus allowing about 30 per cent for the friction of the engine, and the loss of energy in the magneto-electric machine, heating of wires, etc. As Mr. Edison's machine is undoubtedly one of the most efficient now made, it is believed that this estimate will be found practically correct. The experiment on No. 817 was made by observing the photometric power before and after the calorimeter experiment, as two equal lamps could not be found. As the fiber was round, it gave a nearly equal light in all directions as was found by experiment.

Lamps used in		Photometric power		Capacity of Calorimeter in pounds.	Rise of temperature in degrees F.	Energy per minute in foot-pounds.	Mean number of candles per horse power of electricity.	Mean number gas jets of 16 candles each per horse power of electricity.	Mean number of gas jets per indicated horse power.
Calorimeter	Photometer	measured perpendicular to paper, L.	Average, λ						
201	580	17·5	13·1	2·57	1°·75	3486·	109·0	6·8	4·8
580	201	13·5	10·1	2·82	1°·62	3540·			
580	201	38·5	28·9	2·74	2°·44	5181·	204·3	12·8	8·9
201	580	44·6	33·5	2·76	2°·29	4898·			
850	809	19·0	14·3	2·81	1°·14	2483·	133·4	8 3	5·8
809	850	12·2	9·2	2·79	1°·54	3330·			
817			17·2	2·73	1°·28	2708·	209·6	13·1	9·2

The increased efficiency, with rise of temperature, is clearly shown by the table, and there is no reason, provided the carbons can be made to stand, why the number of candles per horse power might not be greatly increased, seeing that the amount which can be obtained from the arc is from 1000 to 1500 candles per horse power. Provided the lamp can be made either cheap enough or durable enough, there is no reasonable doubt of the practical success of the light, but this point will evidently require much further experiment before the light can be pronounced practicable.

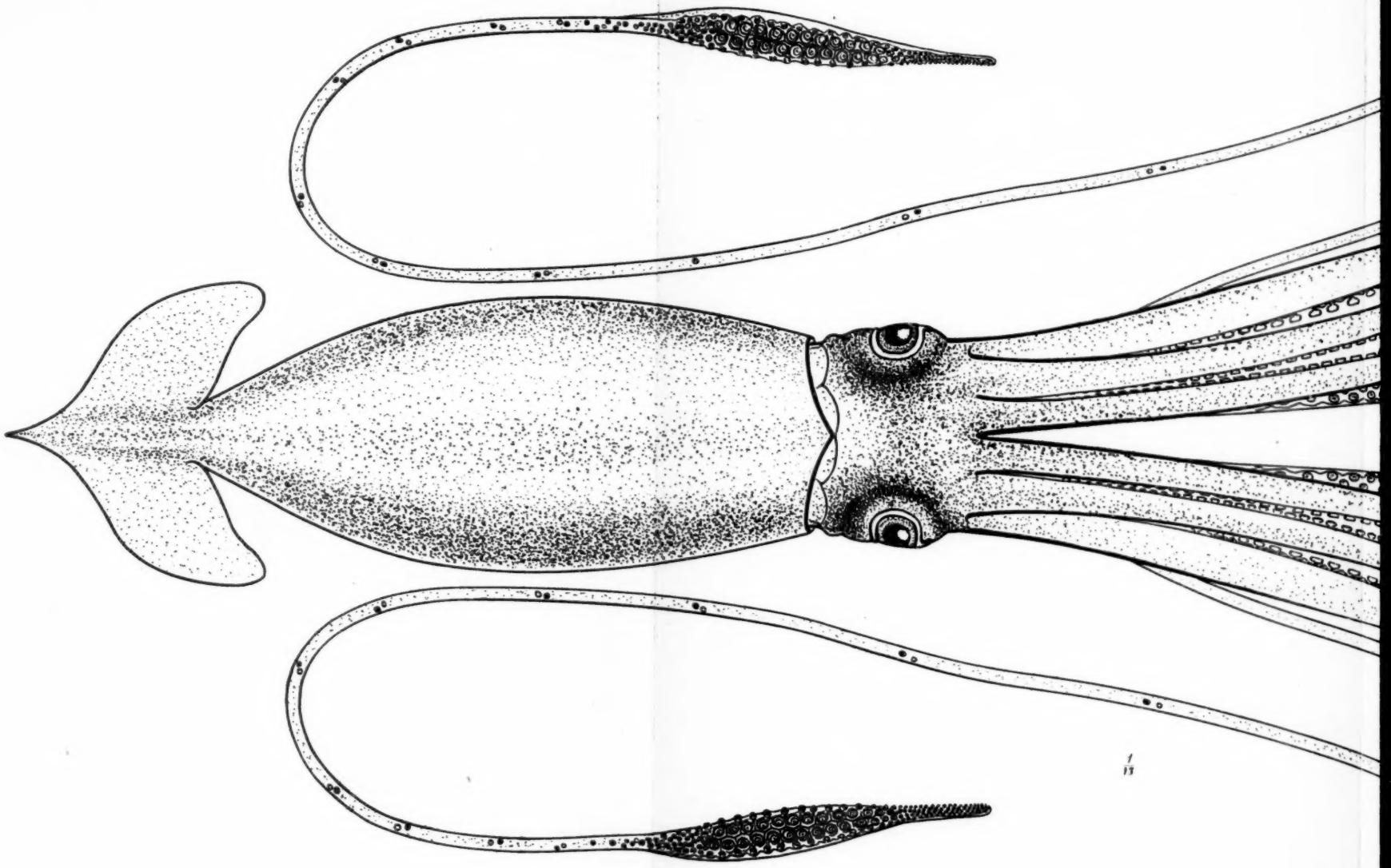
In conclusion, we must thank Mr. Edison for placing his entire establishment at our disposal in order that we might form a just and unbiased estimate of the economy of his light.

OBITUARY.

Professor WILLIAM T. RŒPPER of Bethlehem, Pennsylvania, died on the eleventh of March at the age of seventy. Professor Rœpper was born in the village of Peilau, near the Moravian settlement of Gnadenfrei, in Lower Silesia, Germany, March 7th, 1810. In early life he qualified himself for service in the Moravian Church, and for several years taught at different church schools. He came to America in 1840, at the request of the authorities, to engage in the financial work of the Moravian Church, and was employed in this until 1869, residing most of the time at Bethlehem. At the opening of the Lehigh University in 1866, Mr. Rœpper was appointed Professor of Mineralogy and Geology, and curator of the museum. He retained the professor's chair only three years, discharging his duties with marked success during that time, but he remained curator of the museum until 1871. The latter years of his life were spent in the scientific and historical studies in which he was so much interested.

In the death of Professor Rœpper the science of his adopted country has met with a real loss. Independent of his scientific attainments, he was a man of unusual culture, a thorough scholar in the classics and in history, and an accomplished musician. It was to mineralogy, however, that he especially devoted himself, and in this branch of science he occupied a high position. The mathematical relations of the forms of crystals was a subject to which he gave much study. He was not less diligent in the chemical investigation of minerals, and his thorough knowledge of the practical side of mineralogy caused his opinion as an expert to be frequently sought by those engaged in the mining and smelting of ores. The discovery by him of deposits of zinc ore in the Saucon Valley, Penn., was one which did much to benefit the town in which he resided, but from which he gained nothing himself. He contributed several papers on mineralogical subjects to this Journal; one of these deserves especial mention because a mineral species there described, an iron-manganese-zinc chrysolite from Stirling Hill, N. J., is now called *Rœpperite* after him. Those who knew him well will appreciate that, as the result of his patient work, his contributions to scientific literature might have been much more numerous but for the delicate modesty and lack of desire for outside reputation which characterized him.

Professor Rœpper was a man of most genial and attractive personal character, who will be long remembered by all who had the privilege of his intimate acquaintance.



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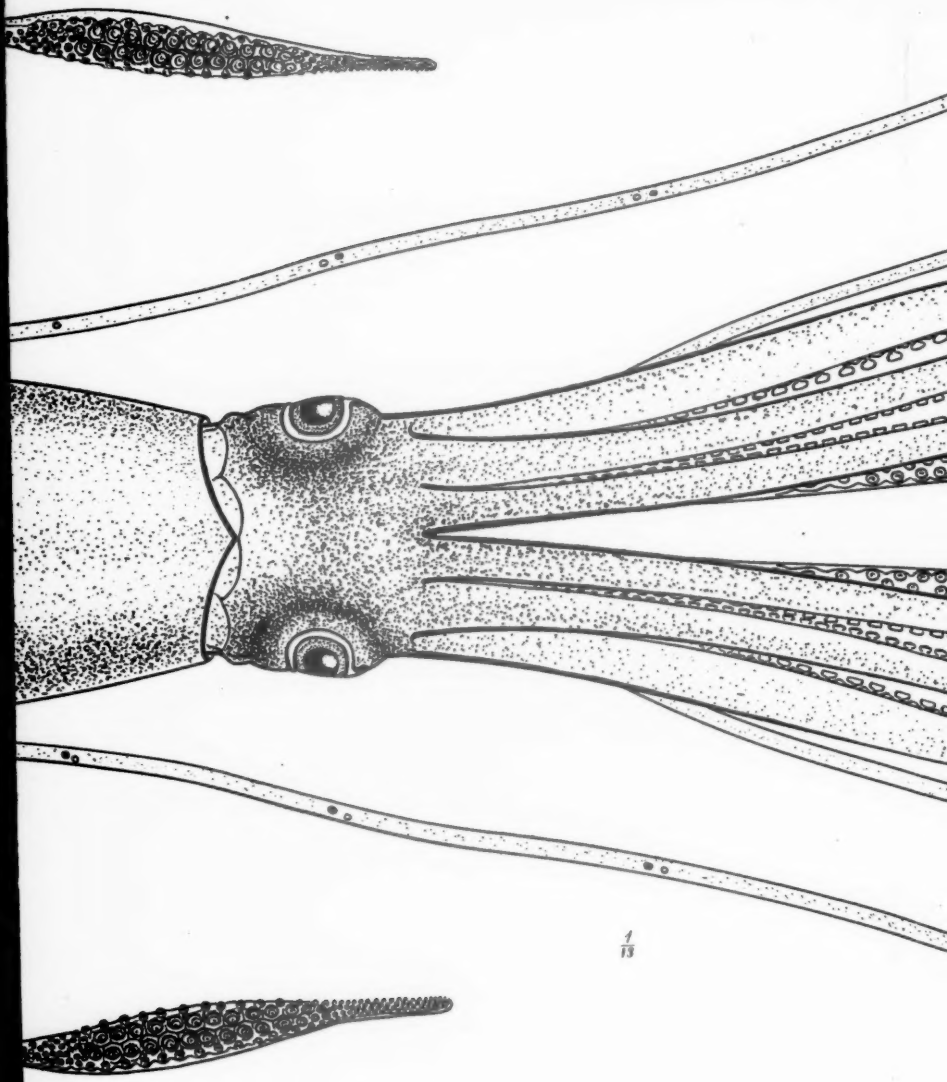

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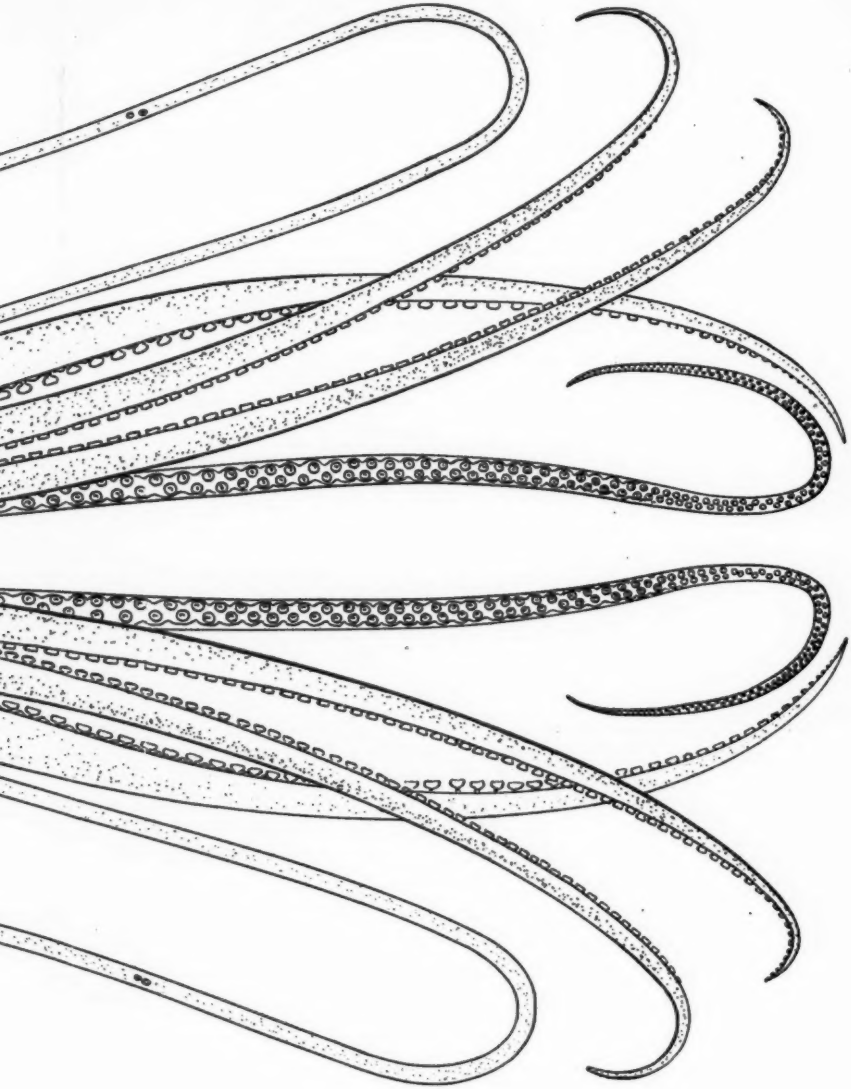

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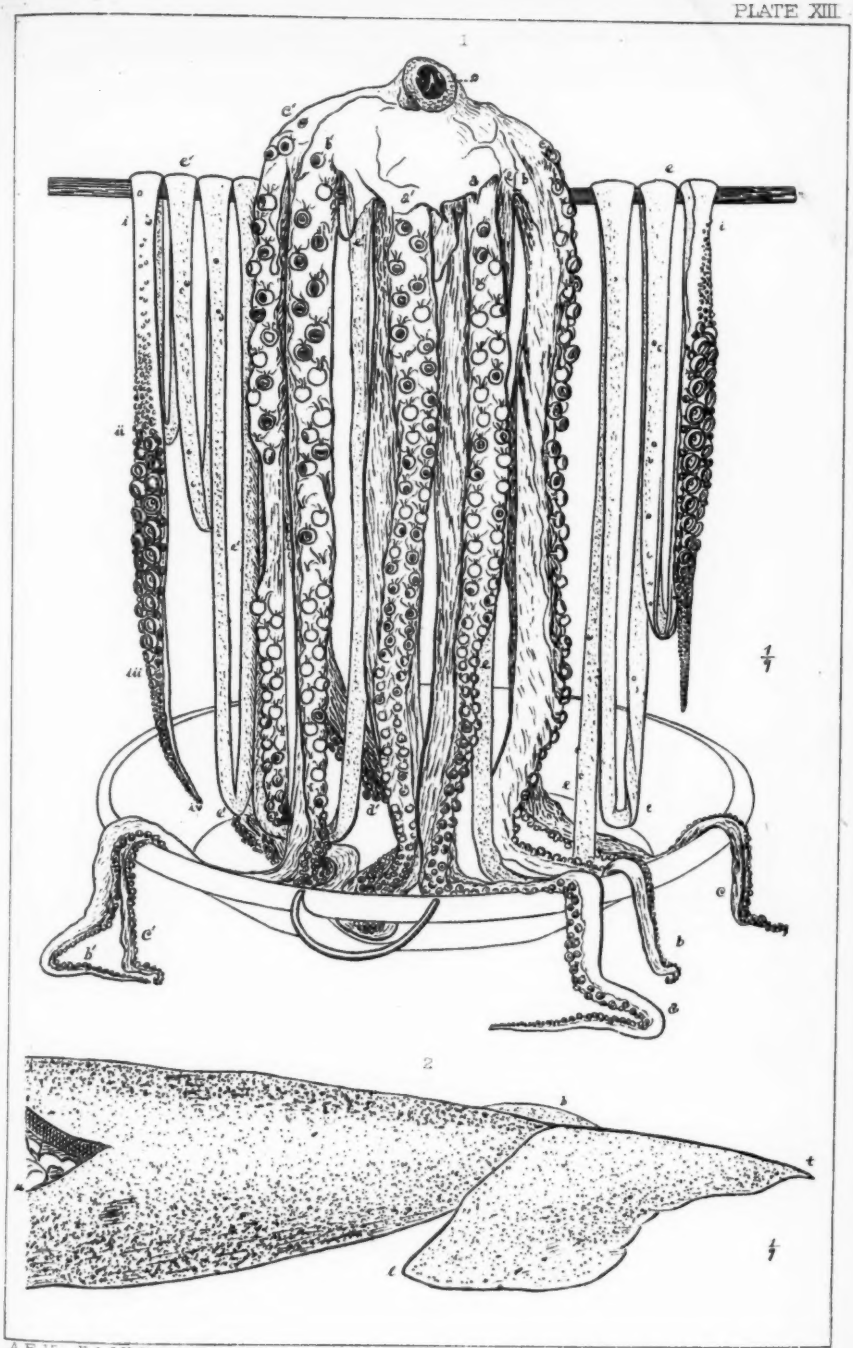

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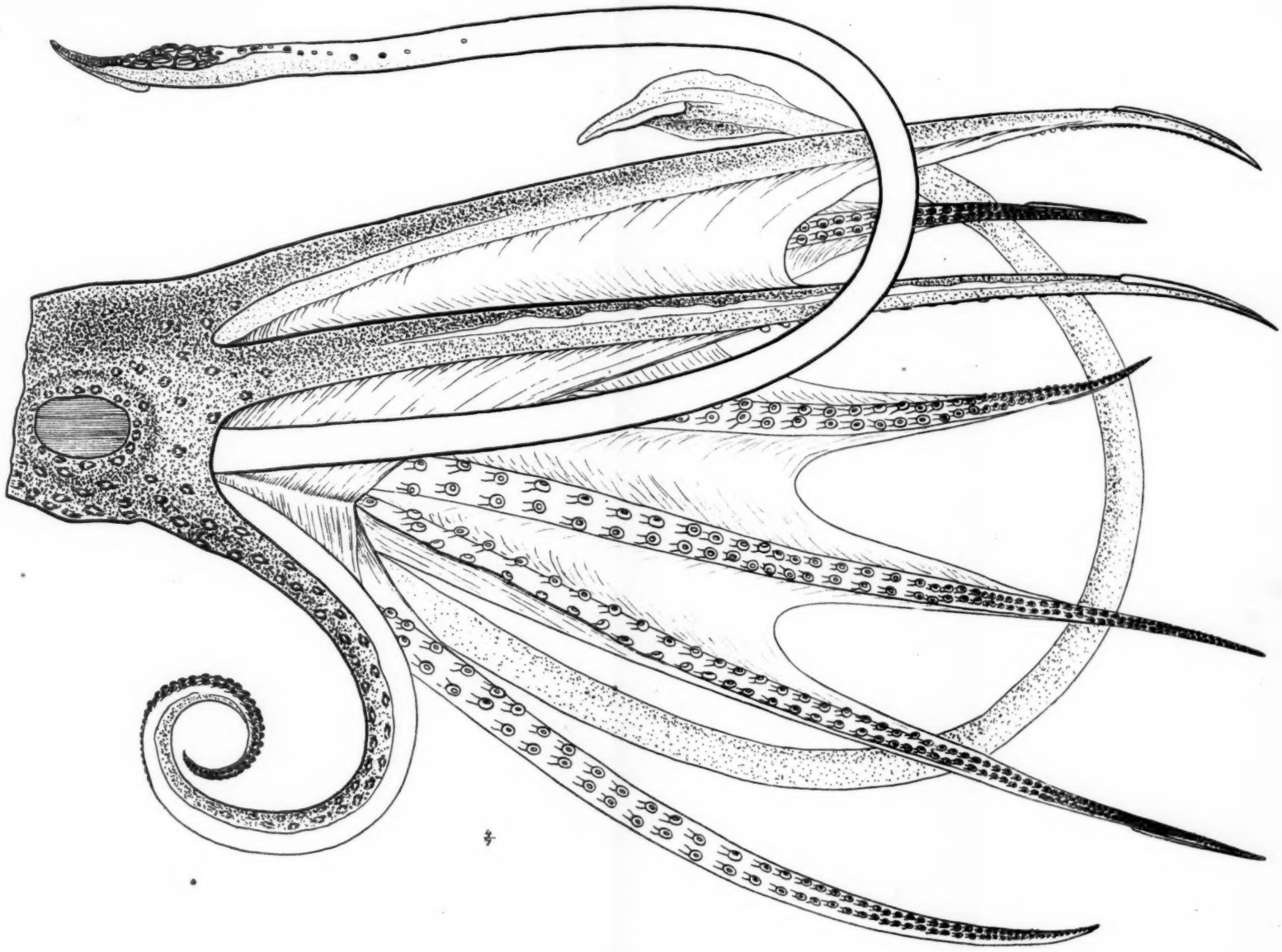

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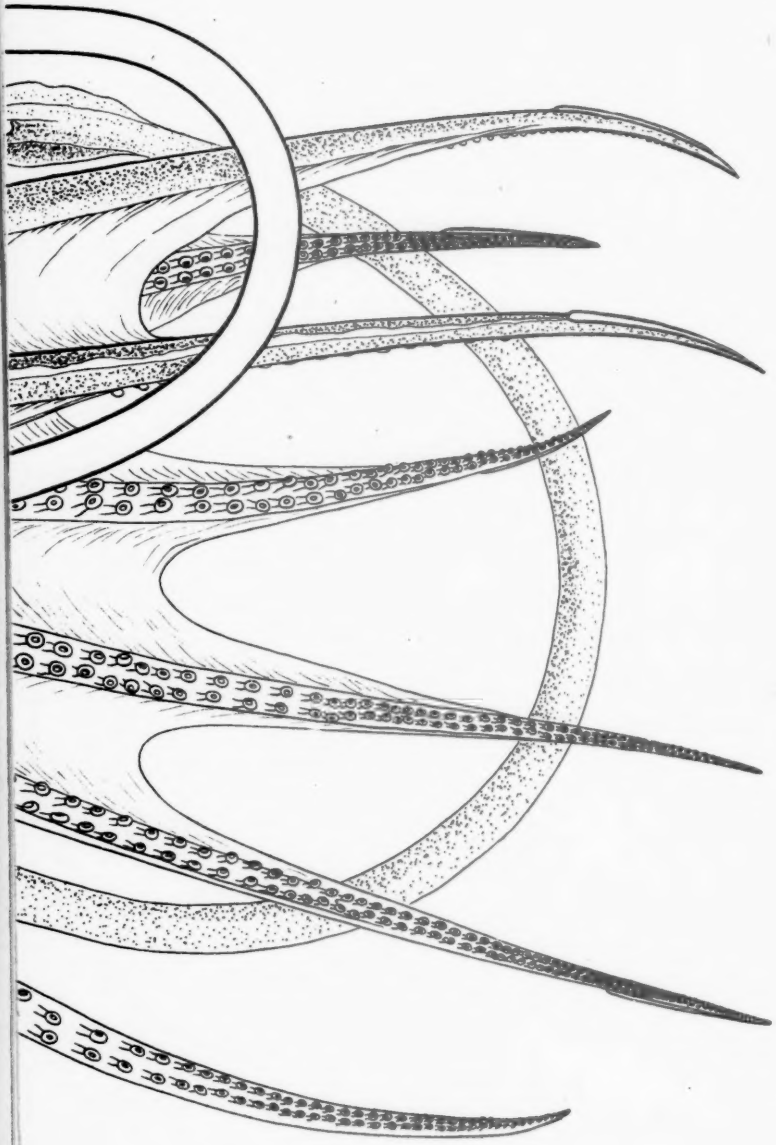

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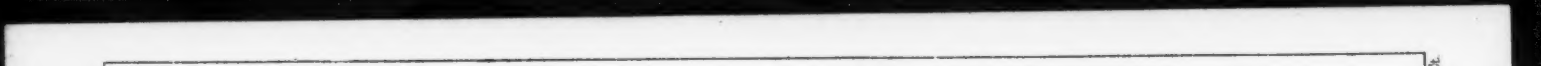
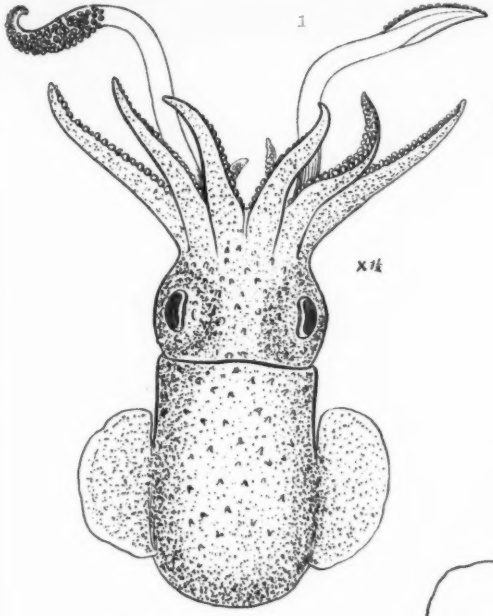
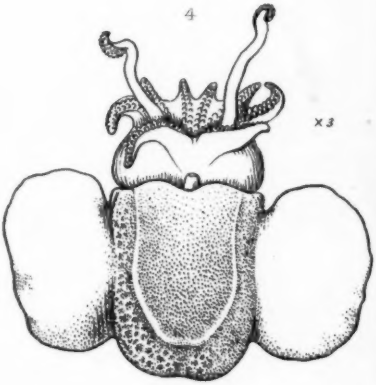
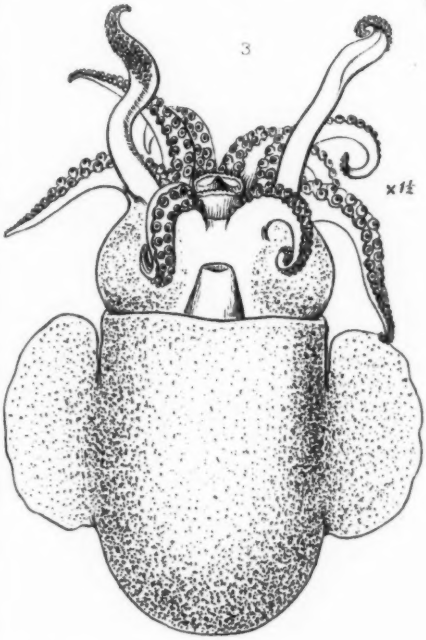
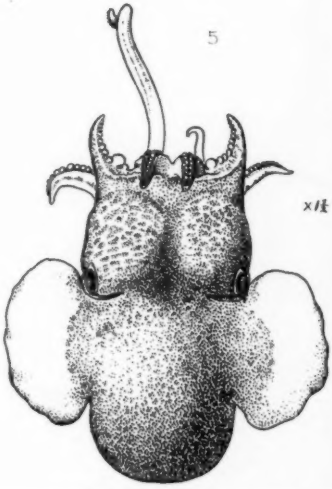




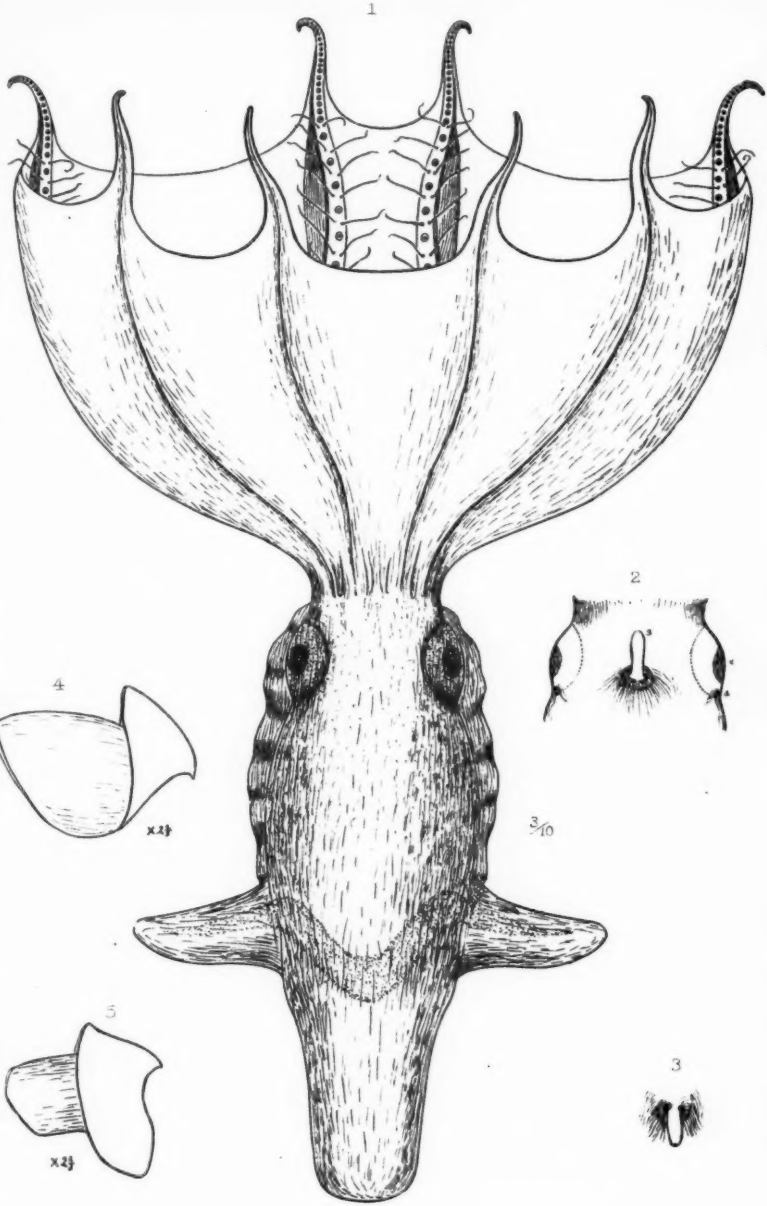






J.H. Emerton from nature.

Photo Lith. Punderson & Crissand New Haven, Ct.



A E Verrill from nature.

Photo Lith. Punderson & Crissand New Haven, Ct.

STAUROTEUTHIS SYRTENSIS VERRILL